REISSUE LITIGATION
Raymond Degner et al.
Reissue Appln. 10/734,073 Filed Dec. 12, 2003
For: COMPOSITE ELECTRODE FOR PLASMA
Protester: Xycarb Ceramics, Inc.
Attorney Docket: 01-9665-06.4 Attorney: John E. Wagner
(818) 957-3340

REISSUE LITIGATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

**DECLARATION OF
JOHN E. WAGNER**

Docket 01-9665-06.4

Name of PROTESTER:	Xycarb Ceramics, Inc.
Address of Protester:	101 Inner Loop Road, Georgetown, TX 78626
Patent Number:	U.S. Patent 5,074,456
Reissue Applicant:	LAM Research Corporation
Title:	COMPOSITE ELECTRODE FOR PLASMA PROCESSES
Serial No.:	10/734,073 (Reissue)
Filing Date:	December 16, 2003

TO THE COMMISSIONER FOR PATENTS

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Honorable Sir:

I, JOHN E. WAGNER, declare as follows:

1. I am an attorney at law and registered patent attorney, Reg. No. 17,496, and attorney for Xycarb Ceramics, Inc., protester in this matter.

2. Accompanying this Protest are the following documents, each of which is a true, and correct copy of the documents provided herewith.

   a) REF. B

      McGuire, SEMICONDUCTOR MATERIAL AND PROCESS TECHNOLOGY HANDBOOK, For Very Large Scale Integration (VLSI) and Ultra Large Scale Integration (ULSI), © 1988, by Noyes Publications, cover, title page, back of the title page, Table of Contents, Introduction, and Chapter 5, Pages 191-328.

   b) ATTACHMENT I

      SUPPLEMENTAL DECLARATION OF PATRICK MICHAEL, IN SUPPORT OF LAM RESEARCH CORPORATION'S APPLICATION FOR TEMPORARY RESTRAINING ORDER

      Pages 1, 2, and first page only of U.S. Patent 4,385,979. The full patent was attached to the original.

   c) ATTACHMENT II

      LAM RESEARCH CORPORATION'S REPLY BRIEF IN SUPPORT OF APPLICATION FOR TEMPORARY RESTRAINING ORDER TO ENJOIN XYCARB CERAMICS, INC. FROM INFRINGING PATENT '456

Cover Sheet

Pages 7 and 8	relevant lines
Page 7	full page
Page 8	lines 1-3.

c) ATTACHMENT III

LAM RESEARCH CORPORATION'S APPLICATION FOR TEMPORARY RESTRAINING ORDER TO ENJOIN XYCARB CERAMICS, INC. FROM INFRINGING PATENT '456

Page 1	
Page 2	relevant portion, lines 3-14
Page 4	relevant portion, lines 12-20
Page 5	relevant portion, full page
Page 9	relevant portion, full page

d) ATTACHMENT IV

McGraw-Hill DICTIONARY OF SCIENTIFIC AND TECHNICAL TERMS, Third Edition, Title, page, back of title page, ©1984

Pages 202 (bond ...)

Page 1267 (Prestress)

Page 1469 (shrink fit and shrink ring)

REISSUE LITIGATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent action thereon.

By John E. Wagner
John E. Wagner

Date: May 8, 2004

I:\Lit\Xycarb\Lam\06.4.DECLARATION OF JOHN E. WAGNER
MAY 6, 2004

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ATTACHMENT I

6-30-03

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Attorneys for LAM RESEARCH CORPORATION

UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

SAN FRANCISCO DIVISION

LAM RESEARCH CORPORATION, Plaintiff, v. SCHUNK SEMICONDUCTOR and XYCARB CERAMICS, INC., Defendants.	**Case No. C 03-01335 CRB** **SUPPLEMENTAL DECLARATION OF PATRICK MICHAEL IN SUPPORT OF LAM RESEARCH CORPORATION'S APPLICATION FOR TEMPORARY RESTRAINING ORDER**

I, Patrick Michael, declare as follows:

1. I am an attorney at law, fully licensed to practice before all of the courts of the State of California, as well as the United States District Court, Northern District of California, and am an attorney with the law firm of Nixon Peabody LLP, attorneys of record for Plaintiff Lam Research Corporation ("Lam"), herein. I have actual knowledge of the facts set forth below, and if called upon to testify, could and would competently testify thereto.

2. Attached hereto as Exhibit 1 is a true and correct copy of U.S. Patent No. 4,385,979, issued on May 31, 1983.

3. Attached hereto as Exhibit 2 is a true and correct copy of U.S. Patent No. 5,014,604, issued on May 14, 1991.

4. Attached hereto as Exhibit 3 is a true and correct copy of U.S. Patent No. 6,419,806 issued on July 16, 2002.

5. Attached hereto as Exhibit 4 is a true and correct copy of an article titled *Investigation of The Press Fit Joints By the Tribology Aspect,* D. Stamenkovi, S. Jovanovi, M. Milosevi, Faculty of Mechanical Engineering, University of Nis, Yugoslavia.

6. Attached hereto as Exhibit 5 is a true and correct copy of a page 250 from the Webster's New International Dictionary, Unabridged (3rd ed. 1981) (relevant portions separately enlarged), which contains definitions of the terms "bond," "bonded" and "bonding."

I declare under penalty of perjury under the laws of the State of California and the United States of America that the foregoing is true and correct.

Dated this 30th day of June, 2003.

By: ______________________
Patrick T. Michael

Exhibit 1

United States Patent [19]

Pierce et al.

[11] **4,385,979**

[45] **May 31, 1983**

[54] **TARGET ASSEMBLIES OF SPECIAL MATERIALS FOR USE IN SPUTTER COATING APPARATUS**

[75] Inventors: **Danny A. Pierce**, Columbus; **Joseph A. Heisler**, Timberlake; **Roger D. Self**, Mount Sterling, all of Ohio

[73] Assignee: **Varian Associates, Inc.**, Palo Alto, Calif.

[21] Appl. No.: **396,580**

[22] Filed: **Jul. 9, 1982**

[51] **Int. Cl.³** **C23C 15/00**
[52] **U.S. Cl.** **204/298**
[58] **Field of Search** **204/298**

[56] **References Cited**

U.S. PATENT DOCUMENTS

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OTHER PUBLICATIONS

J. L. Vossen and W. Kern, "Thin Film Processes", 1978, pp. 31–33, 41–42 and 138–141, Academic Press, New York.

J. van Esdonk and J. F. M. Janssen, "Joining a Sputtering Target and a Backing Plate", Jan. 1975, pp. 41–44, Research/Development.

Primary Examiner—Arthur P. Demers
Attorney, Agent, or Firm—Stanley Z. Cole; Leon F. Herbert; Robert L. Jepsen

[57] **ABSTRACT**

In high rate sputter coating sources, it is generally necessary to liquid cool the sputter targets. In one type of source, a cooled wall of a cathode assembly is closely adjacent a sidewall of the sputter target. During normal operation the sidewall of the target expands thermally into tight contact with the cooled wall, whereby cooling of the target is effected without the need for bonding the target to the cooled wall using a solder or other adhesive. Thus, replacement of worn conventional targets is a relatively simple procedure. When the targets are made of certain special materials, such as fragile materials or materials with low coefficients of thermal expansion, target warping, cracking or melting can occur. Such problems are overcome or alleviated by the novel design approach of the present invention, which employs a sputter target assembly in place of a conventional target. The novel sputter target assembly comprises a sputter target of the special material, a retaining member, and a bonding means between the special sputter target and the retaining member. When the special target is worn out, the sputter target assembly is replaced with the same simple procedure used for a conventional target.

13 Claims, 11 Drawing Figures

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Exhibit 2

United States Patent [19]

Hirao et al.

[11] Patent Number: 5,014,604

[45] Date of Patent: May 14, 1991

[54] PISTON FOR INTERNAL COMBUSTION ENGINE

[75] Inventors: Sumio Hirao; Masaji Matsunaga; Yoshihiro Yamada, all of Kanagawa, Japan

[73] Assignees: Nissan Motor Company, Limited; Atsugi Unisia Corporation, both of Japan

[21] Appl. No.: 421,106

[22] Filed: Oct. 13, 1989

[30] Foreign Application Priority Data

Oct. 14, 1988 [JP] Japan 63-259030

[51] Int. Cl.[5] F02F 3/00

[52] U.S. Cl. .... 92/212; 123/193 P

[58] Field of Search .... 123/193 P; 92/212, 213, 92/222, 231, 176

[56] References Cited

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Primary Examiner—Andrew M. Dolinar
Assistant Examiner—M. Macy
Attorney, Agent, or Firm—Lowe, Price, LeBlanc, Becker & Shur

[57] ABSTRACT

An internally-chilled piston for an internal combustion engine is provided. This piston comprises a piston body made of an aluminum alloy and a piston head including a cylindrical member and a ring-shaped member engaging the outer peripheral surface of the cylindrical member by a shrink fit bonding. The cylindrical member constitutes the central portion of the piston head, while the ring-shaped member constitutes the periphery thereof. On the surface of the ring-shaped member which contacts with the melt forming the piston body during casting, an aluminized layer is formed which chemically connects the ring-shaped member and the piston body to increase the mechanical strength of bonding therebetween.

16 Claims, 3 Drawing Sheets

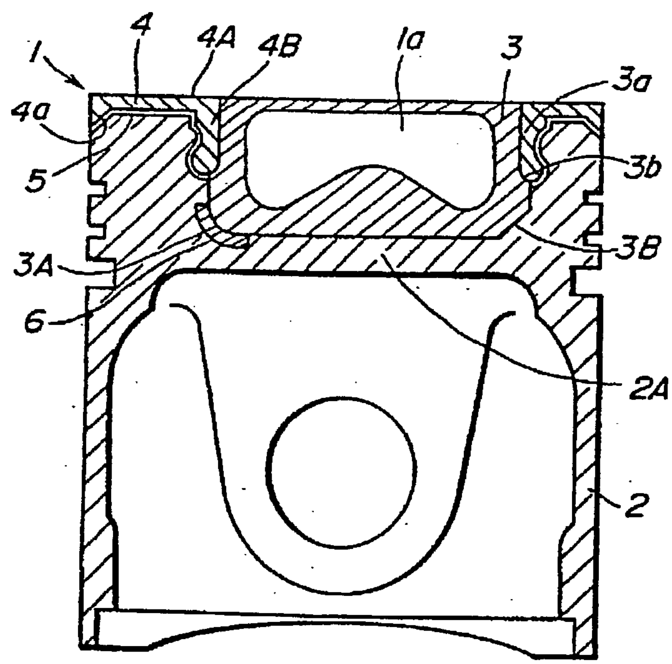


FIG. 1

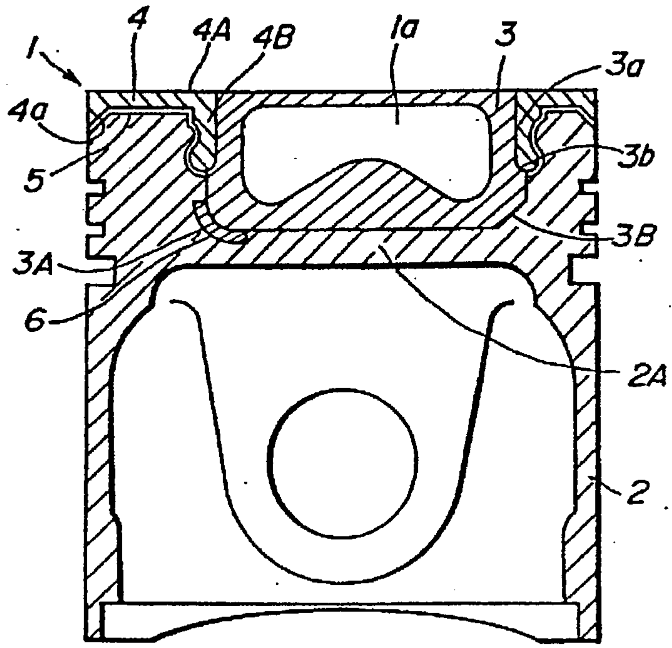


FIG. 2

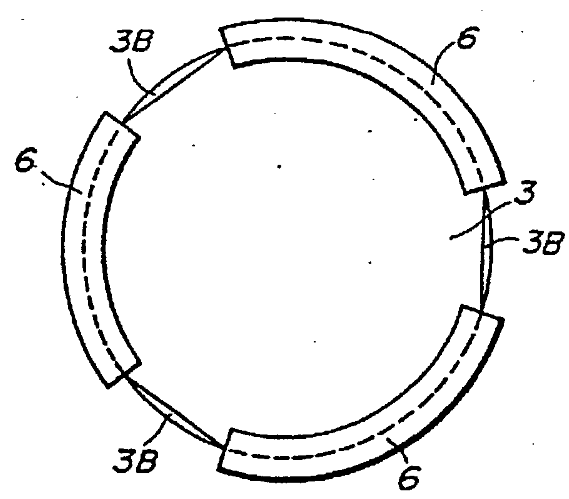


FIG. 3

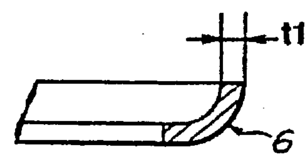

t1
6

FIG. 4

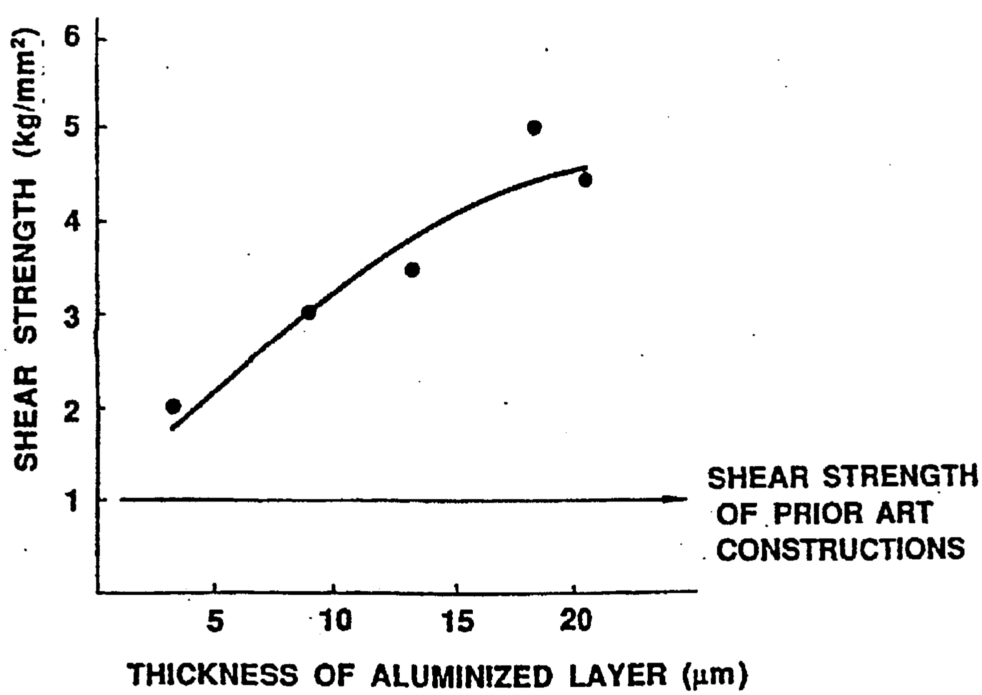

SHEAR STRENGTH (kg/mm²)
6
5
4
3
2
1
SHEAR STRENGTH OF PRIOR ART CONSTRUCTIONS
5
10
15
20
THICKNESS OF ALUMINIZED LAYER (μm)

FIG. 5

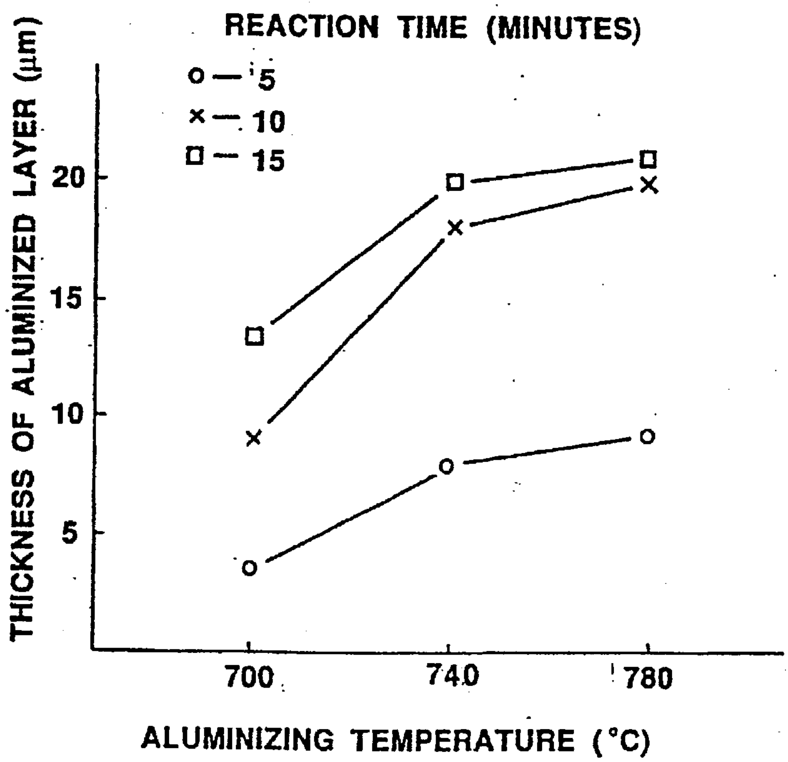
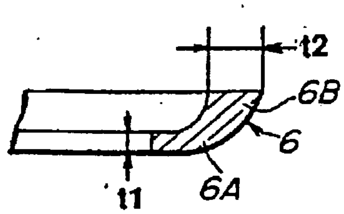

REACTION TIME (MINUTES)
o — 5
× — 10
□ — 15
THICKNESS OF ALUMINIZED LAYER (μm)
20
15
10
5
700
740
780
ALUMINIZING TEMPERATURE (°C)

FIG. 6


t2
6B
6
6A
t1

PISTON FOR INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INvENTION

1. Technical Field of the Invention

The present invention relates generally to a piston for an internal combustion engine, and more particularly to a piston having improved mechanical strength.

2. Background of the Prior Art

As currently available high-powered internal combustion engines for automotive vehicles are developed, the thermal loads exerted on their engine pistons tend to increase. A piston has been accordingly proposed wherein a piston is internally chilled by the inclusion of a ceramic piston head plate during casting of the piston body to improve the heat resistance of the head plate of the piston which faces a combustion chamber of the engine.

However, there is a problem in that the internally chilled surface of the ceramic piston head is separate from the piston body, causing the ceramic piston head to play and to break due to shocks such as piston slap, since the ceramic piston head and the aluminum piston body do not bond well and the difference in thermal expansion therebetween is great. Additionally, the great difference in thermal expansion of the two materials tends to cause residual stress to be exerted on the piston body during cooling after casting. This results in cracking of the piston body.

SUMMARY OF THE INVENTION

It is accordingly an object of the present invention to provide a piston for an internal combustion engine which includes a piston body made of an aluminum alloy and a piston head made of a heat resistant alloy connected with the piston body firmly so as to provide a high mechanical strength of bonding therebetween to produce a high quality piston.

According to one aspect of the present invention, there is provided a piston for an internal combustion engine which comprises a piston head made of heat resistant material, a piston body made of an aluminum alloy, and an aluminized layer formed on a surface of said piston head and interfacing between said piston head and said piston body to connect said piston head with said piston body to improve the mechanical strength of the bond therebetween.

In the preferred embodiment, the piston head includes a first piston head member made of a ceramic and a second piston head member made of a titanium or a titanium alloy. The first head member constitutes the central portion of the piston head, while the second head member constitutes the periphery thereof, the second head member being engaged with the first head member by shrink fit bonding, the aluminized layer being formed on the surface of the second piston head member.

An elastic-plastic member may be further provided. This member is attached to an edge of the first piston head member to absorb stress due to differential thermal expansion between the piston body and the first piston head member during cooling after casting to prevent the piston body from cracking. Additionally, the edge of the first piston head member engaging the piston body may be chamfered to prevent the first head member from rotating relative to the piston body. Alternatively, a plurality of elastic-plastic members may be provided. In this case, the elastic-plastic members are attached to an edge of the first piston head member spaced apart from each other by given intervals to absorb stress due to differential thermal expansion between the piston body and the first piston head member during cooling after casting to prevent the piston body from cracking. A plurality of chamfered surfaces may be provided on the edge of the first piston head member between the elastic-plastic members to prevent the first piston head member from rotating relative to the piston body. It is preferable that the elastic-plastic member is an aluminum fiber molding.

The first piston head member may have a stepped portion on its outer peripheral surface. The second piston head member includes a hollow cylindrical portion into which the first piston head member is fitted and a flange portion on which the aluminized layer is formed. An edge of the hollow cylindrical portion engages the stepped portion so as to prevent the first piston head member from being separated from the piston body.

According to another aspect of the present invention, there is provided a piston for a diesel engine which comprises a piston body made of an aluminum alloy, a first piston head member made of a ceramic, the first piston head member being in the form of a cylinder, a second piston head member made of titanium or a titanium alloy, the second piston head member being approximately ring shaped and engaging the first piston head member by shrink fit bonding, and an aluminized layer formed on a surface of the second piston head member to connect the second piston head member with the piston body to improve the mechanical strength of the bond therebetween.

According to a further aspect of the invention, there is provided a method of producing a piston for an internal combustion engine which comprises the steps of providing a piston head including a first piston head member made of a ceramic and a second piston head member made of titanium or a titanium alloy, the first piston head member constituting a central portion of said piston head and the second piston head member constituting the periphery thereof, the second piston head member being engaged with the first piston head member by shrink fit bonding, the aluminized layer being formed on the surface of the second piston head member, forming an aluminized layer on a surface of said piston, disposing the piston head with the aluminized layer within a mold, pouring a melt of aluminum alloy for forming a piston body into the mold to be bonded to the aluminized layer to form a piston having improved mechanical strength of the bond therebetween.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional side view which shows a piston of a preferred embodiment according to the present invention.

FIG. 2 is a bottom view which shows a ceramic piston head.

FIG. 3 is a side view which shows a fiber member for absorbing differential thermal expansion of a piston body and a ceramic head member during cooling after casting to reduce residual stress.

FIG. 4 is a graph which shows the shear strength of the bonding portion between a titanium alloy and an aluminum alloy relative to the thickness of the aluminized layer.

FIG. 5 is a graph which shows the time required for an aluminizing reaction relative to temperature and the thickness of the aluminized layer.

FIG. 6 is a sectional side view which shows a second embodiment of the fiber member of FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, wherein like numbers refer to like parts in the several views, particularly to FIG. 1, a piston for a diesel engine is shown as an embodiment according to the present invention. This piston 1 comprises generally a piston body 2 made of an aluminum alloy material and piston head including a hollow cylindrical head member 3 and a ring-shaped head member 4. The head member 3 is made of ceramic material and has a cavity 1a in its central portion.

The ceramic head member 3 is made from silicon nitride (Si_3N_4). The material of the head member 3 however may also be an oxide ceramic such as zirconia or aluminum titanate or a non-oxide ceramic such as silicon carbide (SiC) or sialon to obtain heat resistance sufficient for protecting the cavity against great thermal load due to combustion.

The ring-shaped head member 4 is made of titanium (Ti) or a titanium alloy and is engaged with the ceramic head member 3 by shrink fit bonding to form the piston head. However, as a bonding method between the titanium head member 4 and the ceramic head member 3, press fit bonding, heat resistant brazing, or solid-phase bonding may also be used. The titanium head member 4 is L-shaped in cross section including an upper disc plate 4A and an inner cylinder 4B. The ceramic head member 3 includes two sections having outer diameters different from each other. An annular stepped portion 3b is defined by the two sections which receive the lower edge portion of the inner cylinder 4B of the titanium head member to prevent the ceramic head member from being separated, or removed from the piston body 2. The small upper diameter section 3a is fitted into the inner wall of the titanium head member 4. It is preferable that the titanium head member 4 and the ceramic head member 3 are assembled by shrink fit bonding at a predetermined temperature in an inert gas.

On a surface which reaches from the lower surface of the upper disc portion 4A to the outer periphery of the inner cylinder 4B, an aluminized layer 5 is formed before casting wherein aluninum alloy is reacted at a predetermined high temperature. This aluminized layer 5 has a thickness of 15 to 20 (μm) for example and provides an improved mechanical strength of bonding between the titanium head member 4 and the piston body 2 during casting. Before aluminizing, the lower corner of the ceramic head member 3 is faced and fiber moldings 6 are attached thereon as will be describe hereinafter.

The lower edge 3A of the ceramic head member 3 is curved by a predetermined curvature. On this lower edge 3A, as shown in FIG. 2, three chamfered corners 3B are formed at regular intervals to prevent the ceramic head member from rotating relative the piston body 2 after casting.

Bonded to the lower edge 3A by inorganic adhesive are alumina fiber moldings 6. These three fiber moldings are, as shown in FIG. 2, attached to the edges of tne piston head between the chamfered corners 3B. In this embodiment, three chamfered corners are provided, however a different number of chamfered corners may also be formed so as to be exposed between the fiber moldings. The fiber molding 6 is made of alumina fiber and is, as shown in FIG. 3, formed so as to be curved along the lower edge 3A of the ceramic head member 3 with a substantially constant thickness t_1.

For forming the piston 1, an assembly is first provided which is fabricated by fitting the ceramic head member 3 into the ring-shaped titanium head member 4 with a shrink fit bonding. The fiber moldings are attached to the edge of the ceramic head member. Subsequently, the aluminized layer is formed on the titanium head member 4. The assembly is pre-set within a mold for the piston body 2. Then, a melt for forming the piston body is poured into the mold to form the piston 1, i.e., by gravity casting. During casting, the titanium head member is chemically bonded firmly with the aluminum alloy forming the piston body. It is preferable that the fiber moldings 6 are formed with a predetermined porosity such as to prevent the melt from penetrating into it during casting thus providing all the more resiliency.

Therefore, since the titanium head member 4 has the necessary heat resistance against thermal load due to combustion and can provide a light-weight structure for the piston 1, a coefficient of thermal expansion of the head member 4 defined between those of the ceramic head member 3 and the aluminum alloy piston body 2 can be provided to restrict thermal stress occurring during engine operation.

In the aluminized layer 5 formed on the surface 4a between the titanium head member 4 and the piston body 2, the titanium alloy and the aluminum alloy are chemically connected to each other to provide high strength adhesion between the titanium head member 4 and the piston body 2 during solidifying when casting the piston body 2.

Referring to FIG. 4, test results are illustrated which show the shear strength of the bonding portion between the titanium alloy and the aluminum alloy relative to the thickness of the aluminized layer. The results show that an aluminized layer having a thickness of 15 through 20 (μm) can provide sufficient strength under the severe combustion requirements of an engine.

Referring to FIG. 5, test results are illustrated which show the thickness of the aluminized layer with respect to an aluminizing reaction time and the temperature therein. The results show that aluminizing wherein the treating temperature is 700 through 780 degrees C., and the reaction time is 10 to 15 minutes can provide an aluminized layer having a thickness of 15 through 20 (μm).

During aluminizing, since the thermal shock resistance of Si_3N_4, which is the material of the ceramic head member 3, is relatively low, pre-heating in a temperature range of 300 to 400 degrees C. between the aluminizing temperature and the ambient temperature is necessary.

As mentioned previously, the ceramic head member is prevented from being removed from the piston body 2 by the titanium head member 4 and further from rotating with respect to the piston body by the provision of chamfered corners 3B these measures provide mechanical strength sufficient against shock generated during engine operation.

The fiber moldings having impermeability against the melt are highly flexible and the stress due to differential thermal expansion between the ceramic head member 3 and the piston body 2 caused during cooling after cast-

ing is absorbed by elastic-plastic deformation of the fiber molding(s) 6, reducing residual stress occurring in the portion of the piston body 2 facing the lower edge 3A of the ceramic head member 3 to prevent cracking caused by tensile stress from occurring in the thin disc portion 2A of the piston body 2.

Referring to FIG. 6, a second embodiment of a fiber molding 6 is shown. The thickness t_2 of the side wall of this fiber molding 6 connecting with the side wall of the ceramic head member is 1.2 to 3 times the thickness t_1 of the bottom portion 6A connecting with the lower surface of the ceramic head member 3. This allows the fiber molding to be further elastically/plastically deformed, greatly reducing tensile stress affecting the thin disc portion 2A during cooling after the casting of the piston body 2.

As described above, according to the instant invention, a light-weight piston having higher thermal resistance and a higher mechanical strength can be provided. Further, the fiber molding can reduce stress acting on the piston body during cooling to prevent cracks from occurring. Thus, high quality can be obtained.

Although the invention has been shown and described with respect to a best mode embodiment thereof, the piston head including the ceramic head member 3 and the titanium head member 4 may be integrally formed of a heat resistant alloy such as a titanium alloy or a nickel base alloy. In this case, an aluminized layer is formed on the surface of the piston head connecting with the piston body. This piston head is put into a mold for the piston body and then an aluminum alloy is cast to form a piston having the necessary shape.

In this disclosure, there is shown and described only the preferred embodiment of the invention, but, as aforementioned, it is to be understood that the invention is capable of use in various other combinations and environments and is capable of changes or modifications within the scope of the inventive concept as expressed herein.

What is claimed is:

1. A piston for an internal combustion engine, comprising:
- a piston head made of heat resistant material;
- a piston body made of an aluminum alloy; and
- an aluminized layer formed on a surface of said piston head and interfacing between said piston head and said piston body to connect said piston head with said piston body to improve the mechanical strength of the bond therebetween,
- wherein said piston head includes a first piston head member made of a ceramic and a second piston head member made of titanium or a titanium alloy, said first piston head member constituting a central portion of said piston head and said second piston head member constituting the periphery thereof, said second piston head member being engaged with said first piston head member by shrink fit bonding, said aluminized layer being formed on the surface of said second piston head member, and
- wherein the edge of said first piston head member engaging with said piston body is chamfered to prevent said first head member from rotating relative to said piston body.

2. A piston for an internal combustion engine, comprising:
- a piston head made of heat resistant material, said piston head including a first piston head member made of a ceramic and a second piston head member made of titanium or a titanium alloy, said first piston head member constituting a central portion of said piston head and said second piston head member constituting the periphery thereof, said second piston head member being engaged with said first piston head member by shrink fit bonding, said aluminized layer being formed on the surface of said second piston head member;
- a piston body made of an aluminum alloy;
- an aluminized layer formed on a surface of said piston head and interfacing between said piston head and said piston body to connect said piston head with said piston body to improve the mechanical strength of the bond therebetween; and
- an elastic-plastic member attached to a curved edge of said first piston head member to absorb stress due to the differential thermal expansion between said piston body and said first piston head member during cooling in casting to prevent said piston body from cracking,
- wherein the edge of said first piston head member engaging with said piston body is chamfered to prevent said first piston head member from rotating relative to said piston body.

3. A piston for an internal combustion engine, comprising:
- a piston head made of heat resistant material, said piston head including a first piston head member made of a ceramic and a second piston head member made of titanium or a titanium alloy, said first piston head member constituting a central portion of said piston head and said second piston head member constituting the periphery thereof, said second piston head member being engaged with said first piston head member by shrink fit bonding, said aluminized layer being formed on the surface of said second piston head member;
- a piston body made of an aluminum alloy;
- an aluminized layer formed on a surface of said piston head and interfacing between said piston head and said piston body to connect said piston head with said piston body to improve the mechanical strength of the bond therebetween; and
- a plurality of elastic-plastic members attached to an edge of said first piston head member spaced from each other by given intervals to absorb stress due to differential thermal expansion between said piston body and said first piston head member during cooling after casting to prevent said piston body from cracking and a plurality of chamfered surfaces provided on the edge of said first piston head member between said elastic-plastic members to prevent said first piston head member from rotating relative to said piston body.

4. A piston as set forth in claim 3, wherein:
- said elastic-plastic member is an alumina fiber molding.

5. A piston for an internal combustion engine, comprising:
- a piston head made of heat resistant material;
- a piston body made of an aluminum alloy; and
- an aluminized layer formed on a surface of said piston head and interfacing between said piston head and said piston body to connect said piston head with

said piston body to improve the mechanical strength of the bond therebetween,

wherein said piston head includes a first piston head member made of a ceramic and a second piston head member made of titanium or a titanium alloy, said first piston head member constituting a central portion of said piston head and said second piston head member constituting the periphery thereof, said second piston head member being engaged with said first piston head member by shrink fit bonding, said aluminized layer being formed on the surface of said second piston head member, and

wherein said first piston head member has a stepped portion on its outer peripheral surface, said second piston head member including a hollow cylindrical portion into which said first piston head member is fitted and a flange portion on which said aluminized layer is formed, an edge of said hollow cylindrical portion engaging said stepped portion so as to prevent said first piston head member from being separated from said piston body.

6. A piston for a diesel engine, comprising:

a piston body made of an aluminum alloy;

a first piston head member made of a ceramic, said first piston head member being in the form of a cylinder;

a second piston head member made of titanium or a titanium alloy, said second piston head member being approximately ring shaped and engaging said first piston head member by shrink fit bonding;

an aluminized layer formed on a surface of said second piston head member to connect said second piston head member with said piston body to improve the mechanical strength of the bond therebetween; and

a plurality of elastic-plastic members attached to an edge of said first piston head member spaced from each other by given intervals to absorb stress due to differential thermal expansion between said piston body and said first piston head member during cooling after casting to prevent said piston body from cracking and a plurality of chamfered surfaces provided on the edge of said first piston head member between said elastic-plastic members to prevent said first piston head member from rotating relative to said piston body.

7. A piston for a diesel engine, comprising:

a piston body made of an aluminum alloy;

a first piston head member made of a ceramic, said first piston head member being in the form of a cylinder;

a second piston head member made of titanium or a titanium alloy, said second piston head member being approximately ring shaped and engaging said first piston head member by shrink fit bonding; and

an aluminized layer formed on a surface of said second piston head member to connect said second piston head member with said piston body to improve the mechanical strength of the bond therebetween,

wherein said first piston head member has a stepped portion on its outer peripheral surface, said second piston head member including a hollow cylindrical portion into which said first piston head member is fitted and a flange portion on which said aluminized layer is formed, an edge of said hollow cylindrical portion engaging said stepped portion so as to prevent said first piston head member from being separated from said piston body.

8. A method of producing a piston for an internal combustion engine, comprising the steps of:

providing a piston head including a first piston head member made of a ceramic and a second piston head member made of titanium or a titanium alloy, said first piston head member constituting a central portion of said piston head and said second piston head member constituting the periphery thereof, said second piston head member being attached to said first piston head member by shrink fit bonding and retaining means for restricting displacement of the first piston head member with respect to an axially upward direction of the piston;

forming an aluminized layer on a surface of said second piston head member interfacing with a piston body;

disposing said piston head with said aluminized layer within a mold; and

pouring a melt of aluminum alloy for forming a piston body into the mold to be bonded to said aluminized layer to form a piston having improved mechanical strength of the bond between said piston body and said head.

9. A method as set forth in claim 8, wherein:

said retaining means is provided with a stepped portion formed on an outer peripheral surface of the first piston head member and an extending portion of the second piston head member engaging with the first piston head member.

10. A piston as set forth in claim 2, wherein:

the elastic-plastic member comprises a plurality of discrete elastic-plastic sections attached to the edge of said first piston head member spaced from each other by given intervals, the edges of said first piston head member between the elastic-plastic members being chamfered.

11. A piston for an internal combustion engine, comprising:

a piston body, made of aluminum alloy, having a cavity is a central end portion thereof;

a first piston head member made of ceramic, provided in the cavity of said piston body to define a central head portion;

a second piston head member made of titanium or a titanium alloy, defining the periphery of the piston head;

an aluminized layer formed on a surface of said second piston head member and interfacing between said piston body and second piston head member to connect said second piston head member to said piston body; and

retaining means including parts of said first and second piston head members for retaining said first portion head member in the cavity of said piston body.

12. A piston as set forth in claim 11, wherein:

said retaining means is provided with a stepped portion formed on an outer peripheral surface of said first piston head member and an extending portion of said second piston head member engaging with the stepped portion.

13. A piston as set forth in claim 12, further comprising:

a plurality of elastic-plastic members attached to an edge of said first piston head member and spaced from each other by given intervals to absorb stress

due to differential thermal expansion between said piston body and said first piston head member during cooling after casting of said piston body to prevent said piston body from cracking.

14. A method of producing a piston according to claim 8, comprising the further step of:

chamfering a portion of an edge of said first piston head member engaging with said piston body to prevent relative rotation therebetween.

15. A method of producing a piston according to claim 9, comprising the further step of:

attaching an elastic-plastic member to said edge of said first piston head member in selected relationship to said chamfered portion thereof before said disposing step.

16. A method of producing a piston according to claim 9, comprising the further step of:

chamfering a portion of an edge of said first piston head member engaging with said piston body to prevent relative rotation therebetween.

* * * * *

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Exhibit 3

US006419806B1

(12) United States Patent
Holcomb et al.

(10) Patent No.: US 6,419,806 B1
(45) Date of Patent: Jul. 16, 2002

(54) INSERT TARGET ASSEMBLY AND METHOD OF MAKING SAME

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(73) Assignee: Tosoh SMD, Inc., Grove City, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(87) PCT Pub. No.: WO00/32347

PCT Pub. Date: Jun. 8, 2000

Related U.S. Application Data

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(51) Int. Cl.[7] B23K 20/00; C23C 14/34

(52) U.S. Cl. 204/298.12; 204/298.13; 428/636; 428/637; 428/638; 428/650; 428/652; 428/655; 428/658; 428/686; 419/49; 228/141.1; 228/155; 228/190; 228/193; 228/195; 228/199; 228/227; 228/228

(58) Field of Search 204/298.12, 298.13; 428/636, 637, 638, 650, 652, 655, 658, 686; 419/49; 228/141.1, 155, 190, 193, 195, 199, 227, 228

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Primary Examiner—Alan Diamond
(74) *Attorney, Agent, or Firm*—Biebel & French

(57) **ABSTRACT**

Method of forming a two-piece hollow cathode sputter target assembly and the assembly formed thereby. The sputter target assembly includes an outer shell having a substantially cylindrical side wall and is composed of a relatively low purity metallic material. A sputtering insert includes a substantially cylindrical side wall and is concentrically received within, and bonded to, the outer shell. The sputtering insert is composed of a relatively high purity metallic material as used for depositing a thin layer or film onto a desired substrate.

20 Claims, 6 Drawing Sheets

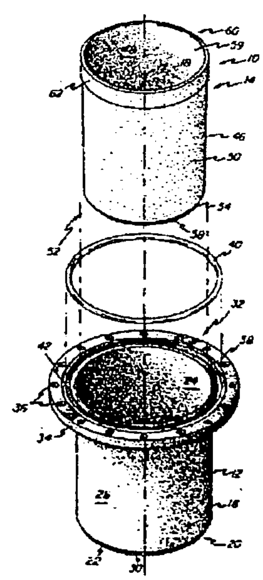

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FIG-1

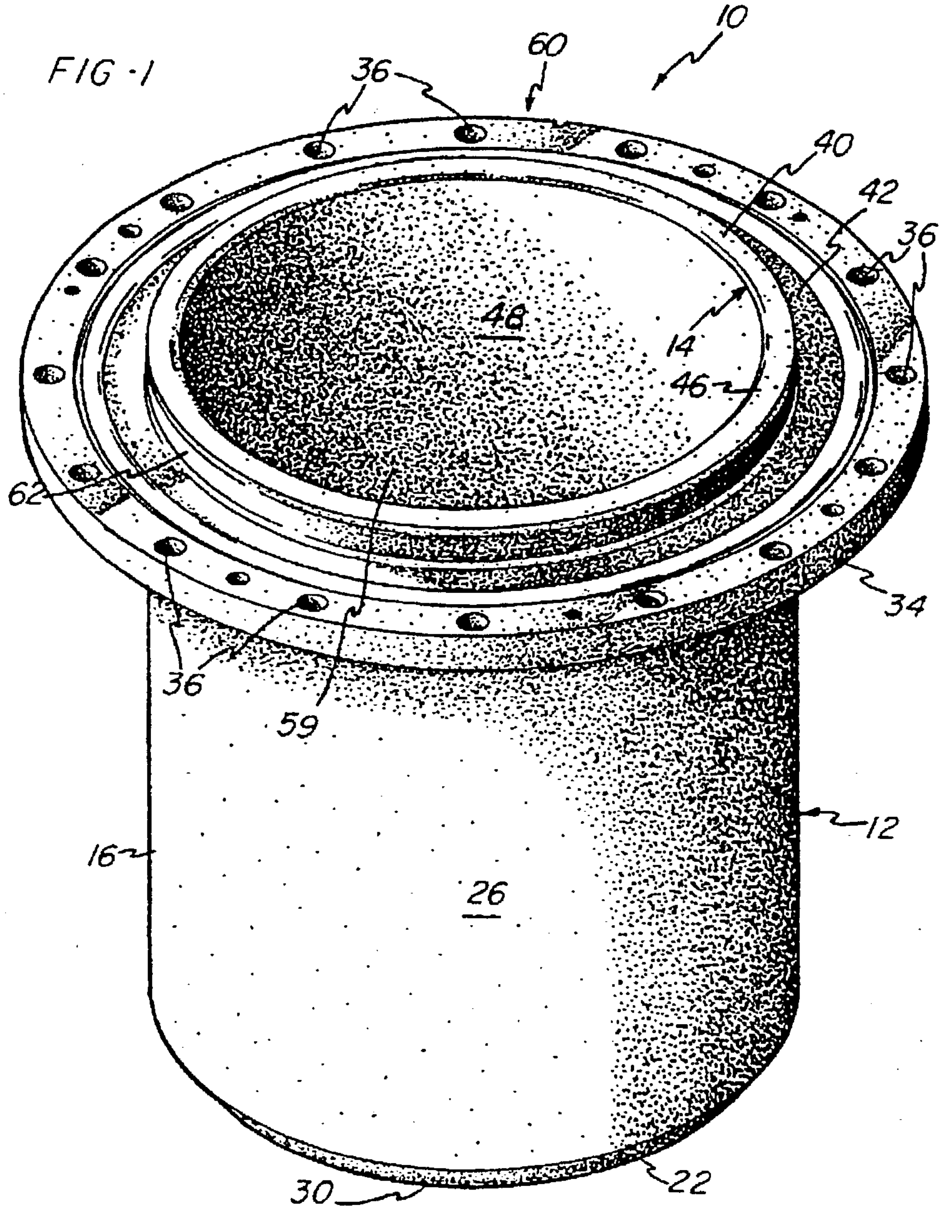

FIG - 2

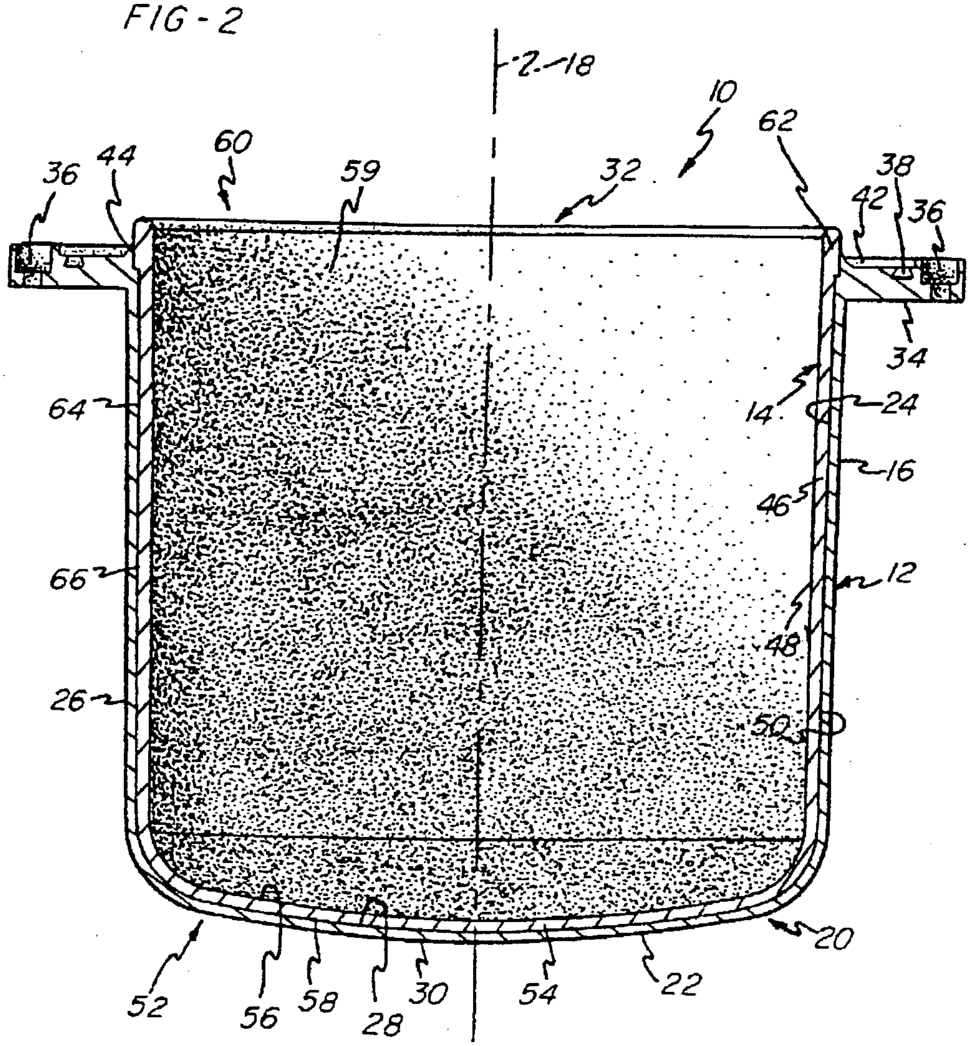
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FIG-3

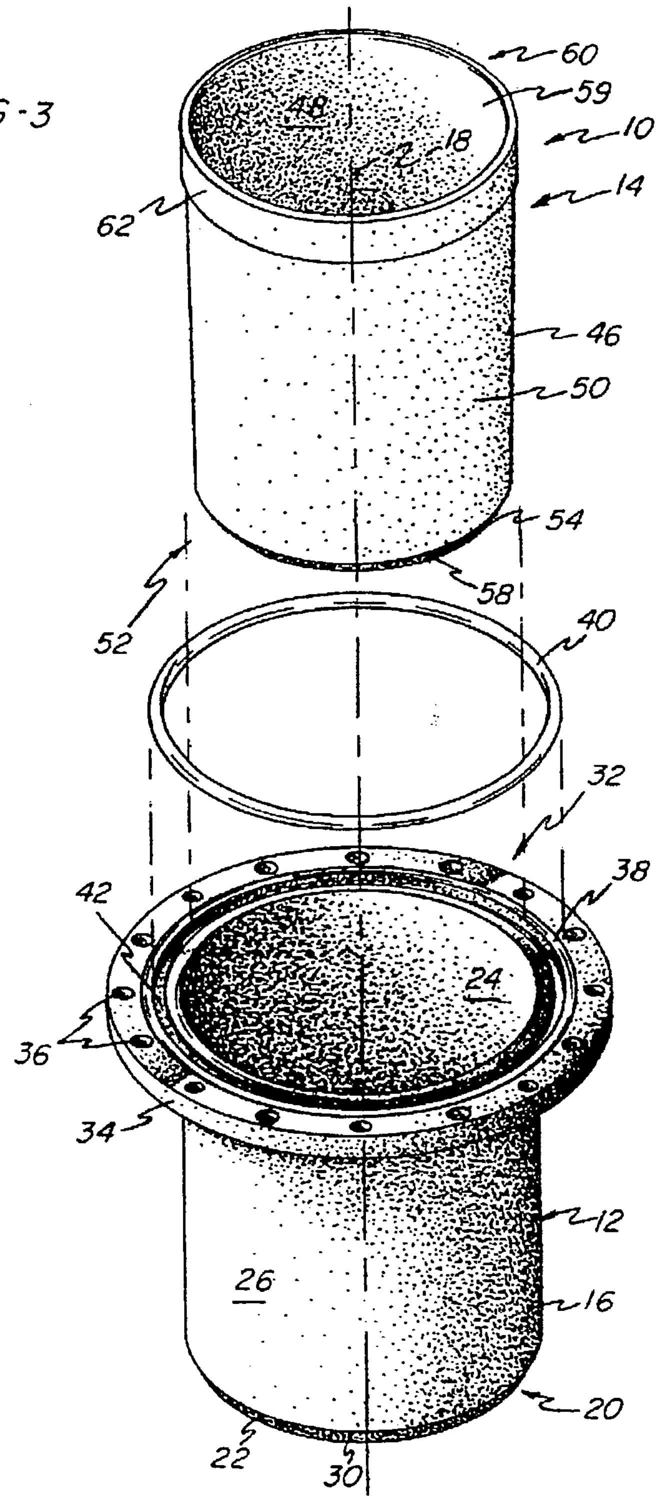
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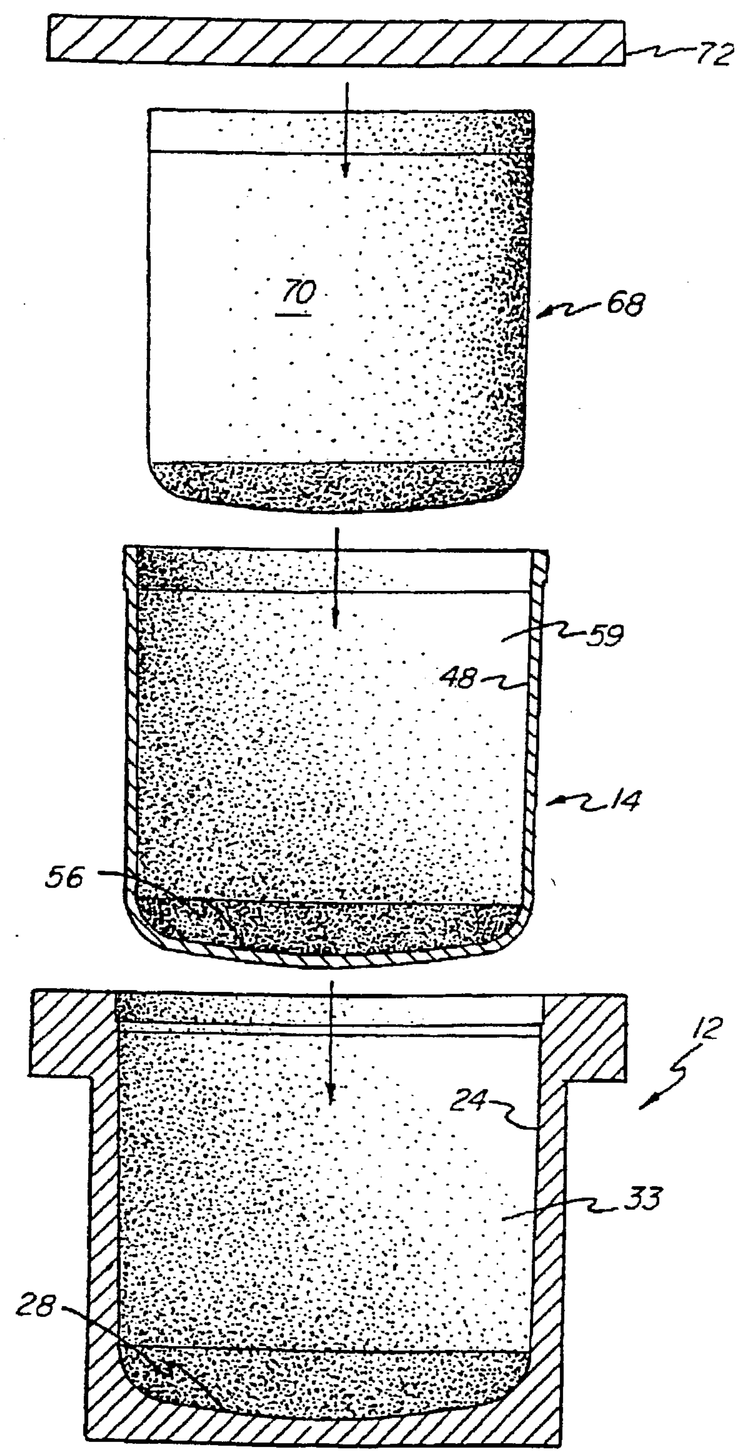
FIG-4



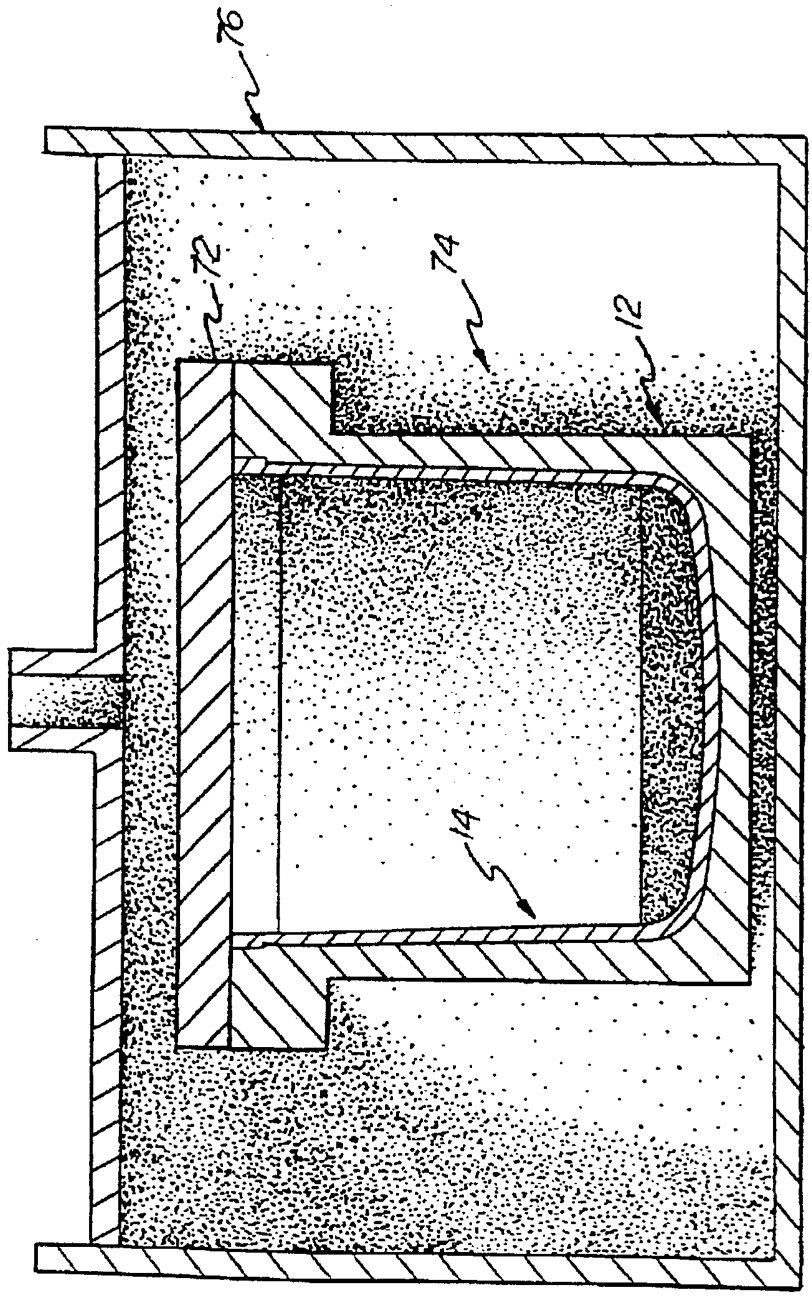
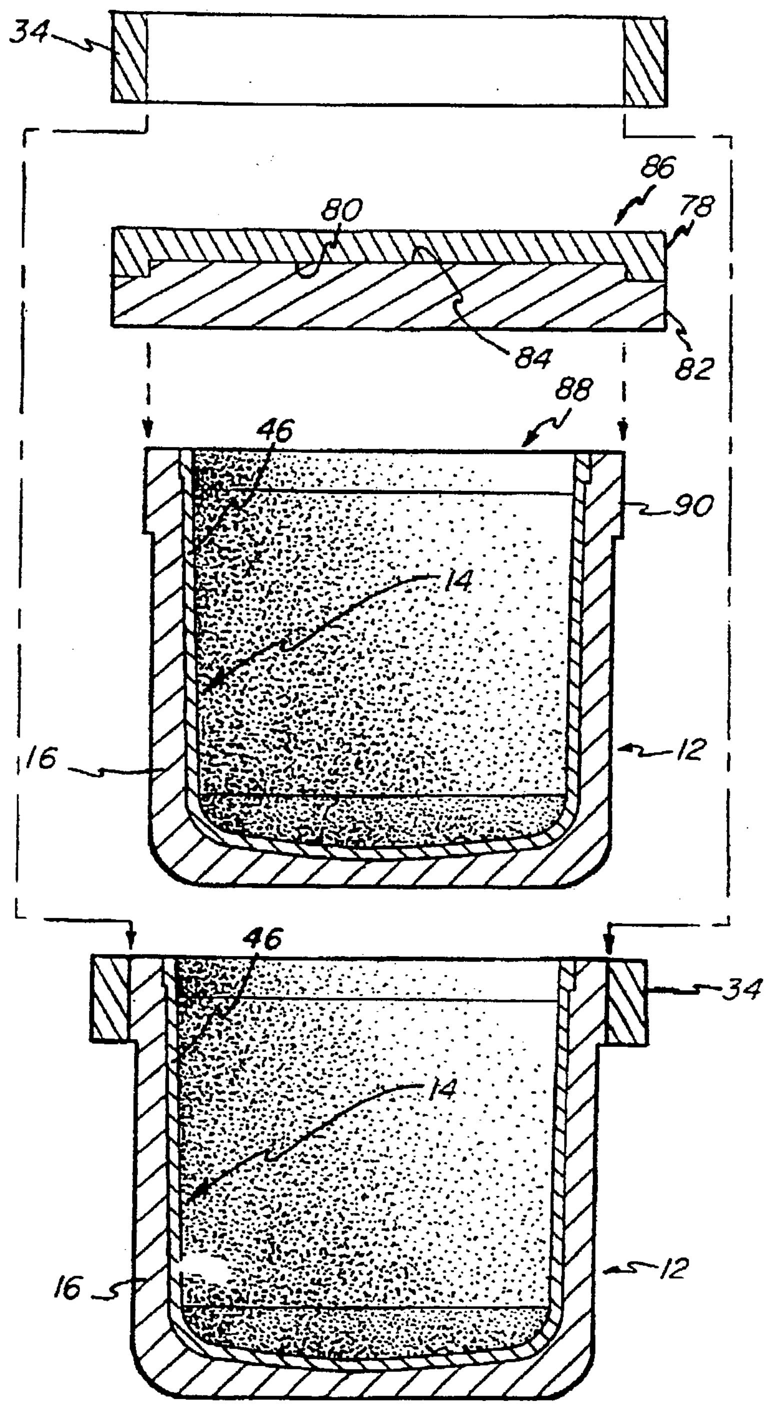


FIG. 5

FIG-6



INSERT TARGET ASSEMBLY AND METHOD OF MAKING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a 371 PCT/US88/28723 filed Dec. 3, 1999, and published under PCT 21(2) in the English language which claims the benefit of U.S. provisional application Serial No. 60/110,765 filed Dec. 3, 1998.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to methods for preparing sputter target assemblies, and to the sputter target assemblies prepared by these methods. In particular, the invention relates to pot-shaped, or hollow cathode, sputter target assemblies, and methods for making such assemblies.

2. Description of the Prior Art

Cathodic sputtering is widely used for depositing thin layers or films of materials from sputter targets onto desired substrates. Basically, a cathode assembly including the sputter target is placed together with an anode in a chamber filled with an inert gas, preferably argon. The desired substrate is positioned in the chamber near the anode with a receiving surface oriented normally to a path between the cathode assembly and the anode. A high voltage electric field is applied across the cathode assembly and the anode.

Electrons ejected from the cathode assembly ionize the inert gas. The electrical field then propels positively charged ions of the inert gas against a sputtering surface of the sputter target. Material dislodged from the sputter target by the ion bombardment traverses the chamber and deposits to form the thin layer or film on the receiving surface of the substrate.

The sputter target is heated during the sputtering process by the thermal energy of the bombarding gas ions. In conventional cathode target assemblies, the target is attached to a nonmagnetic backing plate. The backing plate is typically water-cooled to carry away the heat generated by the ion bombardment of the target.

One type of knows system for coating substrates by cathodic sputtering includes a cathode having a hollow body with an open end facing the substrate and anode. A series of magnets may be provided around the hollow cathode body for optimizing the ionization through magnetic fields. As such, coating coverage and uniformity on the substrate is improved. Examples of such hollow cathode assemblies are illustrated in U.S. Pat. No. 5,985,115 to Hartsough et al. U.S. Pat. No. 4,966,677 to Aichert et al. and U.S. Pat. No. 5,728,280 to Scherer, both of which are incorporated herein by reference.

High purity metal and metal alloys having a purity level greater than that available from commercial grade materials and typically selected form the group including titanium, copper, tantalum, cobalt, tungsten and aluminum, are utilized as the sputtering material in conventional target cathode assemblies. As may be appreciated, such high purity metals and metal alloys are often not readily available and are costly to obtain. Additionally, typical target cathode assembly sputtering materials have relatively high specific gravities resulting in difficulty in their manipulation due to excessive weight.

The above described traditional hollow cathode target assemblies are monolithic in design such that the assembly is formed entirely of the costly and often relatively heavy

high purity metals and metal alloys. Additionally, such hollow cathode target assemblies are generally inefficient in that a significant portion of the sputtering material remains unused when the assembly requires replacement.

Accordingly, there remains a need for a hollow cathode target assembly which increases the efficient use of the expensive high-purity sputtering material and generally reduces the assembly's overall weight. Additionally, there is a need for a method of producing such a hollow cathode target assembly.

SUMMARY OF THE INVENTION

The present invention provides a two-piece pot-shaped, or hollow cathode, sputter target assembly including a sputtering insert of high purity sputtering material which is concentrically received with an outer shell of less expensive, lower purity and preferably, lighter weight material.

More particularly, the invention contemplates a sputter target assembly comprising a sputtering insert including a substantially cylindrical side wall defining a longitudinal axis and having inner and outer surfaces. One end of the 30 sputtering insert is closed by a substantially planar end wall connected to the side wall and having an inner surface connected to the inner surface of the side wall The opposing end of the sputtering insert is open such that the inner surfaces of the side wall and end wall define a cup-shaped sputtering surface.

The sputtering insert is concentrically received within an outer shell. The outer shell includes a substantially cylindrical side wall having inner and outer surfaces. A substantially planar end wall is connected to the side wall at one end of the outer shell and includes an inner surface. The inner surfaces of the side wall and end wall of the outer shell are adapted to mate with the outer surfaces of the side wall and end wall of the sputtering insert along an interfacial area located between the sputtering insert and the outer shell. The interfacial area includes a substantially cylindrical portion extending coaxial to the longitudinal axis.

The sputtering insert is preferably composed of a first metallic material selected from the group consisting of high purity titanium, copper, tantalum, cobalt, tungsten, aluminum and alloys thereof. The outer shell is preferably composed of a second metallic material selected from the group consisting of low purity aluminum, copper, steel, titanium and alloys thereof. The first metallic material has a purity significantly greater than that of a respective second metallic material.

One embodiment of the method of the present invention for forming the above-described two-piece hollow cathode sputter target assembly includes the steps of forming a blank of a first metallic material into a sputtering insert including a substantially cylindrical side wall and an end wall, the side wall and the end wall defining an outer mating surface and an inner sputtering surface. A blank of a second metallic material is formed into an outer shell including a substantially cylindrical side wall and an end wall, the side wall and end wall defining an inner mating surface.

The sputtering insert is positioned concentrically within the outer shell and a substantially cylindrical plug is next positioned concentrically within the sputtering insert. The sputtering insert and plug are then placed within a hot isostatic press can. A closure plate is then secured to the can to form a vacuum tight can assembly wherein residual air is evacuated from the can assembly. The can assembly is then subjected to a predetermined temperature at a predetermined pressure for a predetermined period of time, thereby diffusion bonding the sputtering insert to the outer shell.

A first alternative embodiment of the method of the present invention includes the steps of forming the outer shell and sputtering insert as detailed above but in a manner providing for an interference fit at room temperature. More particularly, the inner diameter of the side wall of the outer shell is selected to be less than the outer diameter of the sputtering insert at ambient room temperature. The sputtering insert is preferably provided at a first predetermined temperature no greater than ambient room temperature and the outer shell is heated to a second predetermined temperature above ambient room temperature. Next, the sputtering insert is slidably received within the outer shell. The sputtering insert is then heated, if necessary, and the outer shell cooled, to ambient room temperature wherein the outer shell contracts, thereby providing an interference fit between the side walls of the sputtering insert and the outer shell at room temperature.

In a second alternative embodiment of the method of the present invention, a substantially planar sputtering blank composed of a first metallic material having a first mating surface is provided. Likewise, a substantially planar shell blank composed of a second metallic material having a second mating surface is provided. The shell blank is bonded with the sputtering blank to form a blank assembly.

Bonding is preferably accomplished by pressing the first mating surface together with the second mating surface at a predetermined temperature below melting points of the first and second metallic materials such that a diffusion bond is formed along the first and second mating surfaces to define a blank assembly. The blank assembly is next formed using traditional metal working methods into a cup-shaped sputter target assembly including an outer shell composed of the shell blank and a sputtering insert composed of the sputtering blank wherein the sputtering insert is concentrically disposed within the outer shell. The sputter target assembly includes an outer cylindrical wall defined by the outer shell and an inner cylindrical wall defined by the sputtering insert wherein the inner cylindrical wall is bonded to the outer cylindrical wall.

Therefore, it is an object of the present invention to provide a hollow cathode target assembly which increases material efficiency by reducing the amount of expensive sputtering material which is not fully processed.

It is a further object of the present invention to provide a hollow cathode target assembly of a reduced weight, thereby facilitating manipulation thereof.

It is another object of the present invention to provide a hollow cathode target assembly which is inexpensive.

It is yet another object of the present invention to provide a method of forming such a hollow cathode target assembly by providing a relatively inexpensive outer shell which concentrically receives a high purity sputtering insert.

It is a further object of the present invention to provide such a method of forming a hollow cathode target assembly which provides adequate bonding strength.

Other objects and advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the sputtering target assembly made in accordance with the present invention;

FIG. 2 is a cross-sectional view of the sputtering target assembly of FIG. 1;

FIG. 3 is an exploded perspective view of the sputtering target assembly of FIG. 1;

FIG. 4 is a diagrammatical view illustrating a series of steps performed in accordance with a first preferred method of the present invention;

FIG. 5 is a diagrammatical view of a hot isostatic press can placed within a hot isostatic pressure chamber, and

FIG. 6 is a diagrammatical view illustrating a series of steps performed in accordance with a second preferred method of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring initially to FIGS. 1–3, the sputter target assembly 10 of the present invention includes an outer shell 12 which is bonded to a sputtering insert 14. The sputtering insert 14 is preferably composed of a first metallic material selected from the group consisting of high purity titanium, copper, tantalum, cobalt, tungsten, aluminum and alloys thereof. This group of first metallic materials have relatively high purity as defined to be greater than that available from commercial grade materials. The particular material utilized for the sputtering insert 14 may be selected from this group based upon a variety of criteria including, but not limited to, etching ability, ease of manufacture, and resistivity. The outer shell 12 is preferably composed of a second metallic material which is selected from the group consisting of relatively low purity aluminum, copper, steel, titanium and alloys thereof. The second metallic material is generally commercial grade and has a purity significantly lower than that of the first metallic material.

The outer shell 12 is cup-shaped and includes a substantially cylindrical side wall 16 defining a longitudinal center axis 18. A first end 20 of the outer shell 12 is closed by a substantially planar end wall 22 connected to the side wall 16 and extending substantially transversely to the longitudinal axis 18. The side wall 16 includes an inner or fast mating surface 24 and an outer surface 26. Likewise, the end wall 22 includes an includes or first mating surface 28 and an outer surface 30. A second end 32 of the outer shell 12 remains open to define an open chamber 33.

The side wall 16 proximate the open second end 32 supports a mounting element comprising an annular flange 34 extending radially outwardly from the side wall 16. A plurality of mounting bores 36 are circumferentially equally spaced around the mounting flange 34. An annular groove 38 extends within the mounting flange 34 from proximate the open second end 32 towards the closed first end 20. A sealing member, preferably an O-ring 40 is received within the annular groove 38 for providing a seal between the outer shell 12 and a wall (not shown) of the sputtering system.

An annular recess 42 is likewise formed within the mounting flange 34 and is in communication with the annular groove 38. The annular recess 42 is adapted to receive an insulating member (not shown) for providing insulation between the outer shell 12 and the wall of the sputtering system. The side wall 16 includes a receiving notch 44 proximate the second open end 32 and extending radially outwardly from the longitudinal axis 18.

The sputtering insert 14 is cup-shaped and concentrically received within the outer shell 12. The sputtering insert 14 comprises a substantially cylindrical side wall 46 having an inner surface 48 and an outer or second mating surface 50. A first end 52 of the sputtering insert 14 is closed by a substantially planar end wall 54 connected to the side wall 46 and extending substantially transverse to the longitudinal axis 18. The end wall 54 includes an inner surface 56 and an outer or second mating surface 58. The inner surfaces 48 and

56 of the side wall 46 and end wall 54 form a sputtering surface which defines an open chamber 59. The side wall 46 proximate an open end 60 of the sputtering insert 14 includes a radially outwardly extending lip 62 for engaging the receiving notch 44 of the outer shell 12. As may be appreciated, the lip 62 provides an extremity for the sputter target assembly 10 consisting solely of the high purity first metallic material of the sputtering insert 14.

The inner or first mating surfaces 24 and 28 of the outer shell 12 are adapted to mate with the inner or second mating surfaces 48 and 56 of the sputtering insert 14 along an interfacial area 64 between the sputtering insert 14 and the outer shell 12. The interfacial area 64 includes a substantially cylindrical portion 66 extending coaxially with the longitudinal axis 18 (FIG. 2).

Turning now to FIGS. 4 and 5, a first preferred embodiment of forming the sputter target assembly 10 of the present invention is illustrated. Initially, the sputtering insert 14 is formed from a blank of the first metallic material through traditional metal working methods. Likewise, a blank of the second metallic material is formed into the outer shell 12 by traditional metal working techniques. These traditional metal working techniques preferably comprise a spinning or deep drawing operation. Once the outer shell 12 and sputtering insert 14 are thus formed, they may be machined to appropriate dimensions as required. It should be noted that through experimentation it has been discovered that the final bonded target assembly 10 may shrink during diffusion bonding such that dimensions of the sputtering insert 14 should be adjusted accordingly to allow for such shrinkage.

Next, a substantially cylindrical solid plug 68 is inserted within the sputtering insert 14. The plug 68 is utilized to prevent the outer shell 12 and sputtering insert 14 from deforming or collapsing during subsequent bonding operations. The plug 68 is preferably composed of aluminum, steel or graphite, wherein aluminum is the preferred material due to its thermal properties, ease of machining and expense. Further, the plug 68 is preferably coated with boron nitride to facilitate its removal following subsequent bonding operations. A 0.005 inch gap is preferably provided between the side walls 16 and 46 of the outer shell 12 and the sputtering insert 14. Likewise, a 0.005 inch gap is preferably provided between the side wall 46 of the sputtering insert 14 and the outer surface 70 of the plug 68.

After the outer shell 12, sputtering insert 14 and plug 68 are all concentrically disposed, a top closure plate 72 is welded to the outer shell 12 to form a can assembly 74 defining a vacuum tight closure, as shown in FIG. 5. The closure plate 72 is preferably welded to the outer shell 12 through electron beam welding in a vacuum atmosphere. This process of electron beam welding in vacuum is well known in the art and there are numerous electron beam welders available on the market which may be utilized for this purpose.

Next, the can assembly 74 is placed within a hot isostatic press (HIP) chamber 76 and is subjected to an HIP process at a predetermined temperature and pressure for a selected time. The can assembly 74 is typically subjected to equal pressure from all sides by means of a pressurizing gas, usually argon. The particular conditions used for the HIP process are selected to meet the requirements necessary to achieve sound bonds between the outer shell 12 and sputtering insert 14.

In a preferred HIP process, the sputtering insert 14 comprises tantalum and the low purity outer shell 12 comprises aluminum. The can assembly 74 may be subjected to a temperature of approximately 565° C. within a range of ±4° C. at a pressure between 10.17 Mega Pascals (MPa) and 10.35 MPa. It is preferred that these parameters be maintained for ±3 hours 0.1 hours. Hot isostatic pressing methods are described in more detail in U.S. Pat. No. 5,234,487, to Wickersham et al. and U.S. Pat. No. 5,230,459, to Mueller et al., the disclosures of which are incorporated herein by reference.

After the HIP process is completed, the closure plate 72 is machined off and the plug 68 removed from within the sputtering insert 14. The assembly may then be machined, if desired, by conventional means to predetermined dimensions for the final sputter target assembly 10.

A second preferred method of bonding the sputtering insert 14 within the outer shell 12 comprises a shrink fit bonding method wherein an interference is provided between the side walls 16 and 46 of the outer shell 12 and sputtering insert 14 at room temperature. More particularly, the steps for providing the shrink fit bond include providing the sputtering insert 14 at a first predetermined temperature no greater than ambient room temperature. The sputtering insert 14 may be cooled to a temperature below ambient room temperature. The outer shell 12 is heated to a second predetermined temperature above ambient room temperature. The sputtering insert 14 at the first temperature is then concentrically placed within the outer shell 12 at the second elevated temperature. Next, the sputtering insert 14 and the outer shell 12 are returned to ambient room temperature by heating and cooling, as required. The outer shell 12 contracts thereby providing an interference fit between the side walls 16 and 46 of the outer shell 12 and the sputtering insert 14 at room temperature. If the sputtering insert 14 is heated from a first temperature below ambient room temperature, it will expand thereby providing additional interference between the side walls 16 and 46.

In a preferred shrink fit method of bonding, the sputtering insert 14 comprises tantalum and the outer shell 12 comprises low purity aluminum. The sputtering insert 14 and outer shell 12 are formed to define an approximate 0.060 inch interference between the outer diameter of the side wall 46 and the inner diameter of the side wall 16 at ambient room temperature. The sputtering insert 14 remains at ambient room temperature of approximately 24° C., while the outer shell 12 is simultaneously heated to approximately 482° C. for about 1 hour. The sputtering insert 14 is then slidably received within the heated outer shell 12. The assembly is then air cooled to ambient room temperature.

Referring now to FIG. 6, a third preferred embodiment of the method of the present invention comprises providing a substantially planar sputtering blank 78 composed of the first metallic material having a first mating surface 80 and providing a substantially planar shell blank 82 composed of the second metallic material having a second mating surface 84. The planar shell blank 82 and planar sputtering blank 78 are bonded together to form a blank assembly 86.

In a diffusion bonding method, the first and second mating surfaces 80 and 84 are pressed together at a predetermined temperature below the melting points of the first and second metallic materials such that a diffusion bond is formed along the first and second mating surfaces 80 and 84. This conventional diffusion bonding method is well known in the art.

In a weld bonding method, a weld is formed along the edge of the shell blank 82 and sputtering blank 78 under vacuum conditions. The weld seals a vacuum between the first and second mating surfaces 80 and 84 thereby bonding the blanks 78 and 82 together. It is important that the first

and second metallic materials be weld compatible, i.e., exhibit similar material properties. As such, it is believed that a preferred combination comprises a first metallic material of high purity copper (about 5–6 N purity) bonded to a second metallic material of low purity copper (about 4 N purity).

The blank assembly 86 so bonded is then formed using conventional metal working techniques into the pot-shaped formed blank assembly 88. The working technique may comprise spinning and/or deep drawing. The sputtering insert 14 is thus concentrically disposed within the outer shell 12 such that the formed blank assembly 88 includes an outer cylindrical wall 16 defined by the outer shell 12 and an inner cylindrical wall 46 defined by the sputtering insert 14 wherein the inner and outer walls 46 and 16 are bonded together.

Next, a ring defining the mounting flange 34 is concentrically disposed over the outer shell 12. The mounting flange 34 is then welded in place to a projecting portion 90 of the side wall 16.

In this alternative embodiment of the method of the present invention, it is preferred that the first metallic material and the second metallic material possess similar metal forming, particularly work hardening, properties to help maintain the bond between the shell blank 82 and sputtering blank 78 during the forming operation.

While the methods herein described and the products produced by these methods constitute preferred embodiments of this invention, it is to be understood that the invention is not limited to these precise methods and products, and that changes may be made in either without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. A sputter target assembly comprising:

a sputtering insert including a substantially cylindrical side wall connected to an end wall, said side and end walls having inner and outer surfaces;

an outer shell including a substantially cylindrical side wall connected to an end wall, said side and end walls having inner and outer surfaces; and

wherein said sputtering insert is concentrically received within said outer shell and said inner surfaces of said outer shell are bonded to said outer surfaces of said sputtering insert thereby forming a substantially pot-shaped sputter target.

2. The sputter target assembly of claim 1 wherein said sputtering insert is composed of a first metallic material selected from the group consisting of titanium, copper, tantalum, cobalt, tungsten, aluminum and alloys thereof.

3. The sputter target assembly of claim 1 wherein said outer shell is composed of a second metallic material selected from the group consisting of aluminum, copper, steel, titanium and alloys thereof.

4. The sputter target assembly of claim 1 wherein said outer shell and said sputtering insert are diffusion bonded together by hot isostatically pressing said outer shell together with said sputtering insert at a temperature and at a pressure for a period of time.

5. The sputter target assembly of claim 1 wherein said outer shell and said sputtering insert are bonded together by an interference fit between said outer and inner cylindrical side walls, said interference fit formed at room temperature.

6. A sputter target assembly comprising:

a sputtering insert composed of a first metallic material, said sputtering insert including a substantially cylindrical side wall defining a longitudinal axis and connected to an end wall, said side and end walls having inner and outer surfaces, said inner surfaces defining a sputtering surface; and

an outer shell composed of a second metallic material, said outer shell including a substantially cylindrical side wall connected to an end wall, said side and end walls having inner and outer surfaces, said inner surfaces of said outer shell adapted to mate with said outer surfaces of said sputtering insert along an interfacial area therebetween to form a substantially pot-shaped sputter target, said interfacial area having a substantially cylindrical portion extending coaxial to said longitudinal axis.

7. The sputter target assembly of claim 6 wherein said first metallic material is selected from the group consisting of titanium, copper, tantalum, cobalt, tungsten, aluminum and alloys thereof.

8. The sputter target assembly of claim 6 wherein said second metallic material is selected from the group consisting of aluminum, copper, steel, titanium and alloys thereof.

9. The sputter target assembly of claim 6 wherein said outer shell and said sputtering insert are diffusion bonded together by hot isostatically pressing said outer shell together with said sputtering insert at a temperature and at a pressure for a period of time.

10. The sputtering target assembly of claim 6 wherein said sputtering insert is concentrically received within said outer shell.

11. A method of forming a sputter target assembly used for forming a film on a substrate, said method comprising the steps of:

forming a blank of first metallic material into a sputtering insert including a substantially cylindrical side wall connected to an end wall, said side and end walls having outer mating and inner sputtering surfaces;

forming a blank of second metallic material into an outer shell including a substantially cylindrical side wall connected to an end wall, said side and end walls having inner mating surfaces;

placing said sputtering insert concentrically within said outer shell; and

bonding said inner mating surfaces of said outer shell to said outer mating surfaces of said sputtering insert thereby forming a substantially pot-shaped sputter target.

12. The method as recited in claim 11 wherein said step of bonding includes pressing said outer shell and said sputtering insert together along said inner and outer mating surfaces at a temperature below the melting points of said first and second metallic materials such that a diffusion bond is formed along said inner and outer mating surfaces.

13. The method as recited in claim 11 wherein said step of bonding includes:

providing said sputtering insert at a first temperature;

heating said outer shell to a second temperature prior to said step of placing said sputtering insert within said outer shell; and

returning said sputtering insert and said outer shell to room temperature after said step of placing said sputtering insert within said outer shell, thereby providing an interference fit between said side walls of said sputtering insert and said outer shell at room temperature.

14. A method of forming a sputter target assembly comprising:

providing a sputtering insert including a substantially cylindrical side wall and an end wall, said side wall having an outer mating surface and an inner sputtering surface, said sputtering insert composed of a first metallic material;

providing an outer shell including a substantially cylindrical side wall having an inner mating surface, said outer shell composed of a second metallic material;

placing said sputtering insert concentrically within said outer shell; and

pressing said outer shell and said sputtering insert together along said inner and outer mating surfaces at a temperature below melting points of said first and second metallic materials such that a diffusion bond is formed along said inner and outer mating surfaces.

15. The method as recited in claim 14 wherein said step of pressing includes the steps of:

placing a plug concentrically within said sputtering insert;

placing said sputtering insert and plug within a hot isostatic press can;

securing a closure plate to said can to form a vacuum tight can assembly;

evacuating residual air from said can assembly; and

subjecting said can assembly to a temperature and a pressure for a period of time.

16. The method as recited in claim 15 wherein said temperature is about 565° C., said pressure is about 10.17 MPa and said time is about 3 hours.

17. The method as recited in claim 14 wherein said first metallic material is selected from the group consisting of titanium, copper, tantalum, cobalt, tungsten, aluminum and alloys thereof.

18. The method as recited in claim 14 wherein said second metallic material is selected from the group consisting of aluminum, copper, steel, titanium and alloys thereof.

19. The method as recited in claim 15 wherein said plug is composed of a material selected from the group consisting of aluminum, steel, graphite and alloys thereof.

20. The method as recited in claim 15 wherein said outer shell forms said hot isostatic press can.

* * * * *

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Exhibit 4

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INVESTIGATION OF THE PRESS FIT JOINTS BY THE TRIBOLOGY ASPECT

UDC 620.178.16:66.068

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Abstract. *The strength of a press fit joint represents static friction force that is the biggest force that can be transmitted by means of this joint. The real strength of a press fit joint can only be determined by loading the joint up to the moment of parts separation. However, in projecting phase of engineering practice calculation of the press fit joint strength is often necessity. In order to reliable estimate the press fit joint strength it is necessary to know real value of static friction coefficient. Calculation method of press fit joints as specific tribomechanical systems with experimental investigation of their friction coefficient values is given in this paper.*

Key words: *tribology, press fit joints, friction force, friction coefficient.*

1 Introduction

Press fit joints have simply form and way of assembling and because of that they have application in projecting of transport vehicles. A press fit joint represents a bond between two parts in contact and it is realized by the static friction effect that is caused by mutual pressure acting on their contact surfaces.

The strength of a press fit joint represents static friction force. In fact this is the biggest force which can be transmitted from one to another part in contact. Because of that, a press fit joint represents a specific tribomechanical system. The most important feature of this tribomechanical system is it's real strength.

Press fit joints such as gear-shaft, bearing-shaft, wheel-axle, brake disc-axle and so on are very important mechanical parts. This is because the strength of a press fit joint directly has influence on safety of transport vehicles.

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2. THE STRENGTH OF A PRESS FIT JOINT

The real strength of press fit joint can only be determined by loading the joint up to the moment of parts separation. The value obtained in this way is different from the one obtained theoretically by means of calculation. This is the cause of the unreliability in choosing the coefficient friction value, estimating the real joint interference and calculating the contact pressure.

In Fig. 1. is given an overview of parameters and features that have influence on contact pressure and friction coefficient and in that way on the strength of a press fit joint.

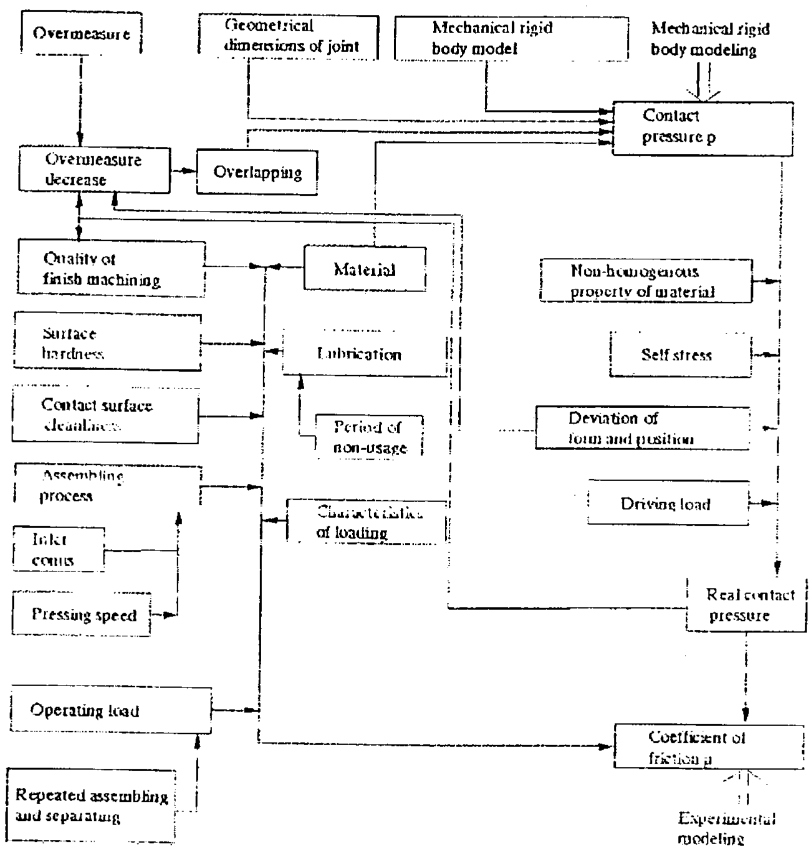

Fig. 1. Influencing parameters and features on press fit joint strength

The next formula is in use for the press fit joint strength calculation:

$$F_\mu = \mu F_N = \mu p A = \mu p \pi d l \tag{1}$$

It can be seen that increasing in press fit joint strength can be obtained by the increase of the joint diameter (d), length of the press fit joint (l), contact pressure (p) and friction coefficient (μ). The increase of the joint diameter and length causes the increase of the volume as well as the weight of the unit and in this way the increase of the whole construction proportions. On the basis of the previous an engineer must avoid the increase of the press fit joint strength in this way.

The contact pressure can be increased by performing larger joint interference or by increased stiffness of parts in a joint. The increase of the contact pressure is limited by material yield strength point of parts in a press fit joint.

The friction coefficient value has large interval of possible values and depends on a lot of parameters. These are: nature and properties of used material, value of the contact pressure, lubricant film properties, contact surfaces roughness, contact time, presence of the extraneous bodies in contact zone and so on. Friction coefficient can be increased using some technological acts and surfaces treatment. However, the friction coefficient value must be limited for the purpose of assembling and separating press fit joint parts without performing damages on parts contact surfaces.

There is unreliability in defining the strength of a press fit joint. This comes mainly from unreliability in defining the value of coefficient of friction for the concrete instance. An investigation has been carried out at the Faculty of Mechanical Engineering in Ni{ in which static friction coefficient has been studied.

For example, taking into account recommendations for choosing the interference values in the case of press fit joints for railway vehicles the larger contact pressure value can have mostly two times bigger value then the smallest one. If different kinds of lubricant and different condition of pressing to make a press fit joint are taken into account, the biggest value can be five times bigger than the smallest one (6). Therefore, the strength of press fit joint can be change greatly with frictional features changing.

3. CALCULATION OF A PRESS FIT JOINT

In calculation of press fit joints start point is working load. This load is very important because it causes tangential and/or axial forces on parts surfaces in contact in a press fit joint. With the purpose to transfer these forces from one part to another it is necessary to obtain existence of a force that can resist sliding between the parts in contact. The force between parts in a press fit joint that does that is called friction force. Elastic deformations on parts in contact caused by the existence of interference cause contact pressure that than produces this force. Calculation of a press fit joint should give the interference value that ensures mentioned conditions that is nominal values and parts tolerances of a press fit joint.

An algorithm in Fig. 2 shows the calculation method of elastic loaded cylindrical press fit joints. Some input data for the calculation depend on the construction demands. The others are obtained by measuring or adopted from the recommendations.

A computer program for press fit joints calculation has been made on the basis of the shown algorithm. Faculty of Mechanical Engineering as well as Mechanical Industry find this program very useful for this purpose.

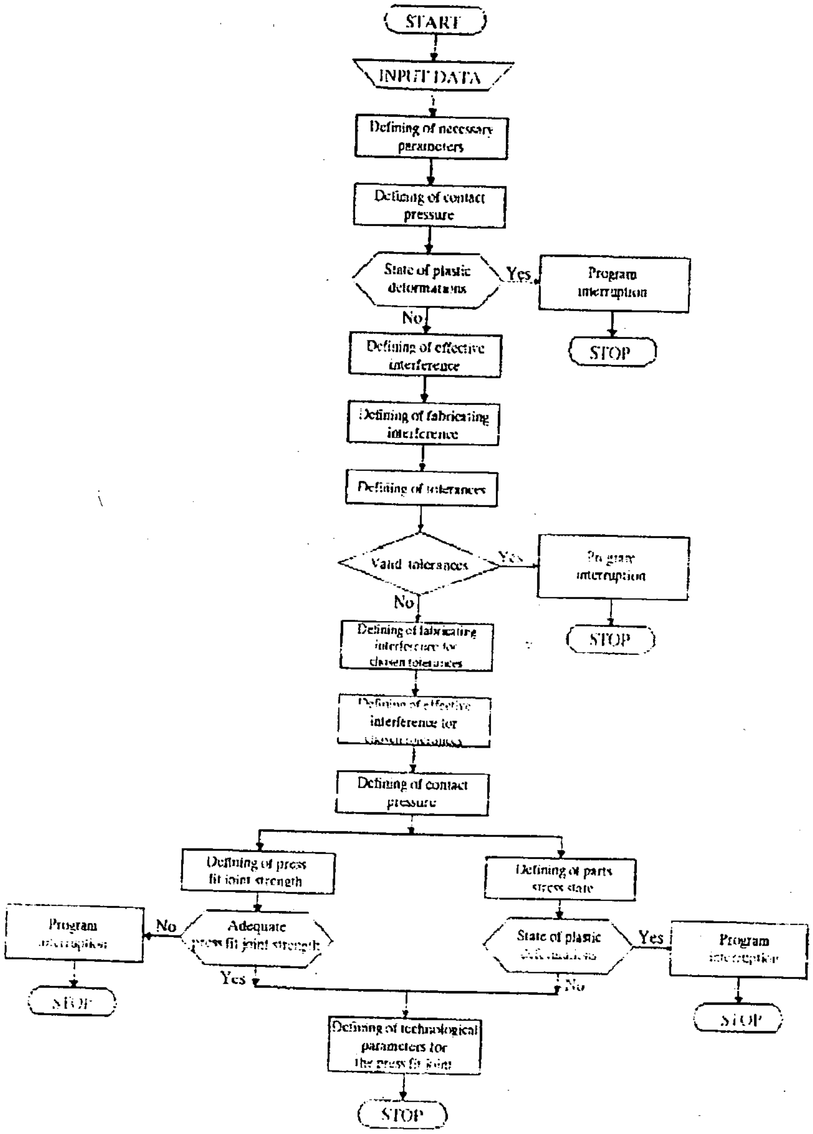

Fig. 2. Press fit joints calculation algorithm

4. THE EXPERIMENTAL INVESTIGATION

In the case of static friction establishing the friction coefficient value can be done only in very short period of time, that is in the very start moment of sliding. The static friction force is tangential resistance force that appears during so-called boundary relative displacement. The relative displacement proceeds to the visible, macro displacement. Taking into account this fact, static friction force can be measured only in the very moment of sliding beginning. This is for the reason that in the next moment, after sliding has started, this static friction force changes into kinetic one. This process can be explained by conditions of forming micro-connections and it has stohastical (accidental) character.

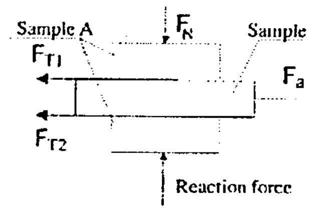

Fig.3. Schematic review of experimental model

Experimental model for establishing static friction coefficient, projected specially for this type of investigation, is shown on Fig. 3. On this base, the measuring equipment was made and investigation was done with samples in the form of plates.

Taking into account this experimental model static friction coefficient can be established by formula:

$$\mu = \frac{Fa}{2F_N} \tag{2}$$

In this way static friction coefficient is established by two measuring force values (F_a and F_N) and because of that this value is very reliable. On the other hand, the next formula is often used for friction coefficient calculation for cylindrical press fit joints:

$$\mu = \frac{F}{p\pi dl} \tag{3}$$

The values obtained by this formula are somewhat unreliably because of the fact that the contact pressure value is not measured but just approximately calculated.

Experimental investigation was executed in two separate parts. The aim of the first experiment was examining the influence of the surface roughness and hardness on the static friction coefficient. This was done with samples in the form of plates by the measuring equipment specially made for this occasion, as it is shown on Fig. 4.

This measuring equipment should offer conditions for measuring vertical load force (F_N) and longitudinal force (F_a). The last force represents friction force in the beginning of the sample parts sliding. Except forces it should be enabled to measure displacements of sample parts too. This is important because it is necessary to record force just in the moment when the sample parts begin mutually moving.

The method named measuring mechanical values by electrical way is used. This method is reliable and respectable in modern metrology. For this purpose program BEAM 3.1 is especially useful and it was used for this experiment.

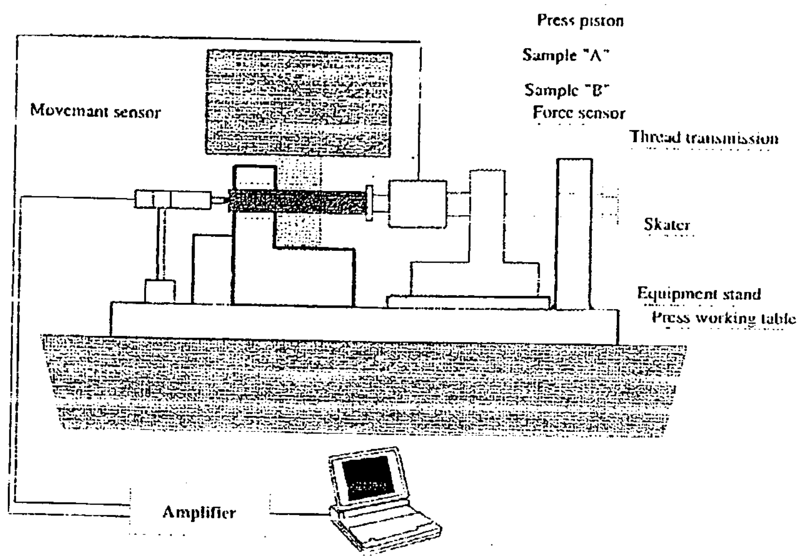

Fig.4. Schematic review of measuring place for measuring static friction force

Force-movement diagram obtained in the experimental process is shown on Fig. 5.

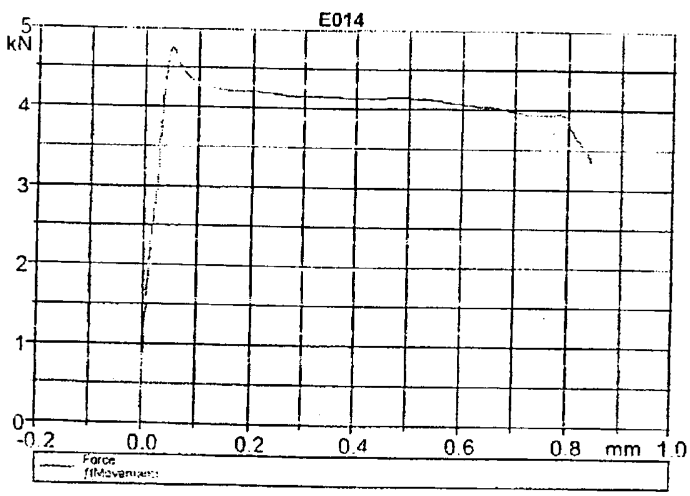

Fig.5. Force-movement diagram of sample plates sliding process

The second part of the experiment is performed with press fit joint samples. First, press fit joints were assembled as force fit joints and, a few days after, samples were separated by means of press force. The friction force and the displacements of sample parts were recorded during the process of assembling and separating.

The separating process of a press fit joint sample continued about 40 seconds. However, the sliding beginning moment happened in very short period of time, such as it was in the case of plates sliding in the first part of the experiment.

Typical experimental force-movement diagram at the beginning of a press fit joint parts separating process is shown on Fig.6.

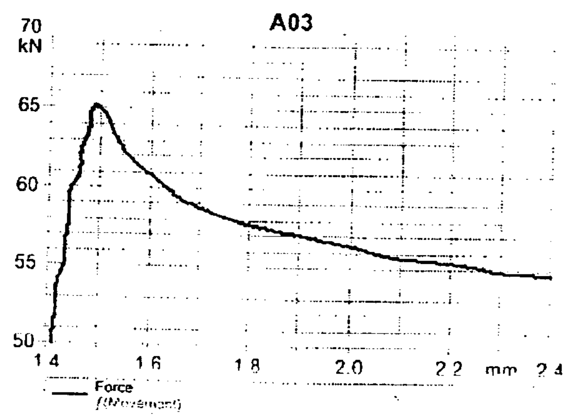

Fig.6. Force -movement diagram at the beginning of a press fit joint parts separating

The experimental investigation has shown that properties of applied lubricants and contact surfaces roughness have specially great influence on the static friction coefficient value as well as on the real strength of press fit joints [6]. With different lubricants that were applied on press fit joint samples with similar contact surfaces roughness of parts static friction coefficient values were in an interval from 0,047 up to 0,259. The values of static friction coefficient obtained with press fit joint samples that were lubricated with the same lubricant together with changing in contact surfaces roughness were between 0.123 and 0.226. Moreover, when samples in the form of plates with varying in contact surfaces roughness and lubricated with the same lubricant were used the range 0,051 to 0,126 was obtained for the values of static friction coefficient.

5. Conclusion

On the basis of the results obtained in the experiment it can be generally concluded that press fit joints must be treated as specific tribomechanical system. It is very important to have knowledge of tribological parameters that can influence strength of a press fit joint and in this way to ensure good loading transmit.

The strength of a press fit joint, that is the static friction force, is very difficult to identify precisely. That is because it depends on plenty parameters and features that have stohastical (accidental) character. Performed investigation indicates that for the responsible press fit joints that are loaded with huge loads and produced in high series it is necessary to perform an experiment for testing the friction coefficient value for the concrete tribological circumstances (the way of assembling the press fit joint, the way of machining contact surfaces, applied lubricant, surface hardness and so on).

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ISTRAŽIVANJE PRESOVANIH SPOJEVA SA TRIBOLOŠKOG ASPEKTA

Dušan Stamenković, Slobodan Jovanović, Miloš Milošević

Nosivost presovanih spojeva predstavljena je silom statičkog trenja koja predstavlja najveću silu koja se može preneti ovim spojem. Stvarna nosivost presovanog spoja se može jedino odrediti opterećivanjem spoja do trenutka razdvajanja delova u spoju. Međutim, u inžinjerskoj praksi je veoma često neophodno u fazi projektovanja sračunati nosivost presovanog spoja. U cilju da se što pouzdanije proceni nosivost presovanog spoja potrebno je poznavati stvarnu vrednost statičkog koeficijenta trenja. U ovom radu je dat tok proračuna presovanih spojeva kao specifičnih tribomehaničkih sistema zajedno sa eksperimentalnim istraživanjem vrednosti njihovih koeficijenata trenja.

Ključne reči: *tribologija, presovani spojevi, sila trenja, koeficijent trenja.*

4

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6/27/03

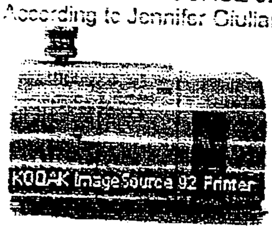
MITSUI CHEMICALS AMERICA, INC.

Press Release

Business Machinery/Copiers - November 5, 1997

EASTMAN KODAK COMPANY ADOPTS MITSUI'S AURUM® THERMOPLASTIC POLYIMIDE FOR HIGH-SPEED COPIER FUSER ROLL END-CAP

Eastman Kodak Company (Rochester, NY) has adopted insert molded AURUM Thermoplastic Polyimide end caps for the fuser roll assembly of the KODAK 3100 Duplicator high speed copy machines and KODAK LIONHEART Power Printing Systems including the KODAK 1392 Printer and KODAK IMAGESOURCE 92p Printer. According to Jennifer Giuliano of engineering plastics manufacturer Mitsui Chemicals, Inc. (Purchase, NY), AURUM is an extreme heat resistant thermoplastic polyimide designed to withstand high loads and high velocities at temperatures exceeding 500°F which can be conventionally injection molded to tight and consistent tolerances using high-performance injection molding machines. The AURUM® insert molded end caps are supplied by Pixley Richards, Inc, a leading custom injection molder of high - temperature thermoplastics to the automotive, business machinery, and electronics industries. The powder metal insert over which the AURUM polyimide is injection molded to form the composite end cap is manufactured by Alpha Sintered Metals.



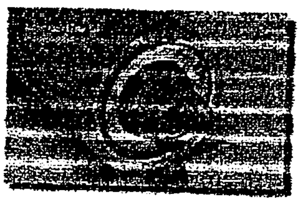
The end cap, also known as a gudgeon, has traditionally been an all-plastic component

During development of the AURUM/metal composite gudgeon, approximately 200 composite gudgeon prototype samples were insert molded by Pixley Richards and supplied to Kodak for life testing in machines, with one lifetime equivalent to approximately 1 million copies. A number of manufacturing issues were addressed by Pixley Richards. Primary, was the development of a capable interface **between** AURUM and the stainless steel insert. Pressures, temperatures, and fill rates were adjusted to achieve the correct balance producing a solidly knit part, while not overstressing the stainless steel insert which forms a significant part of the cavity. AURUM demonstrated an ability to withstand a wide variety of processing conditions. Care was needed during these trials to ensure that the ultimate process parameters would also be capable in high-volume production manufacturing

Ian MacLeod, the Vice President of Engineering at Pixley Richards acknowledged, "There are limits when processing high performance materials. AURUM seems to allow you to stretch those limits better than many other performance materials." Once positive, field performance results for the first 200 AURUM/metal composite gudgeon samples were confirmed, another 800 production-quality samples were molded by Pixley Richards for field machine testing by Kodak.

injection molded from a high heat resistant polyimide -- most recently AURUM. In the electrostatic-type copier, an AURUM gudgeon is attached to each end of a fuser roll core made of a thermally conductive material such as aluminum. The aluminum core is heated internally by a quartz lamp, and the actual fusing surface of the fuser roll that permanently fixes the toner to paper or transparencies is typically made of a thermally conductive polymer, such as silicone rubber. The gudgeon is responsible for transferring rotational motion and for providing support to the frame of the machine. In addition, the gudgeon acts as a thermal barrier to protect an expensive steel bearing, positioned **between** the gudgeon and frame, from excessive heat transfer. The gudgeon also provides a low friction, wear resistant surface to extend the life of the bearing. In operation, the gudgeon is subject to operating temperatures of 450°F, with spikes as high as 480°F, and torque levels of 60 ft lbs.

AURUM Thermoplastic Polyimide was chosen by Eastman Kodak Company



as the plastic component of a metal/plastic composite fuser roll assembly end cap in the KODAK 2100 Duplicator high speed copier and ImageSource 92 printer (pictured above). AURUM® was selected for its ability to withstand operating temperatures of 450°F with spikes to 480°F at torque levels of 60 ft lbs. Click here or the image for larger version. (Image size, 22.2kb)

As a cost-reduction project, a high-performance metal/plastic composite gudgeon was designed in 1995 by Kodak engineers. The patent for the AURUM /metal composite gudgeon, filed in December 1995 by Allen Kass and Robert Lancaster both employees of Kodak, was issued July 22, 1997 (US Patent No.5.649891). The composite gudgeon consists of glass fiber reinforced AURUM Thermoplastic Polyimide injection molded onto a powder metal insert made of grade 303 stainless steel. The reinforced AURUM compound is supplied by RTP Company (Winona, MN), a compounder of thermoplastic materials including the RTP 4200 Series of AURUM materials. The composite gudgeon also provided a variety of functional advantages including low thermal conductivity of the metal section and extended component life. The strong **bond between** the AURUM and metal insert is derived from a combination

According to Allen Kass, Product Engineer for Roller Development & Manufacturing at Kodak, AURUM was selected over an extensive list of other engineering plastics, including PPA and PPS, for the all-plastic and subsequently metal /plastic composite gudgeons, "because of the good stability of AURUM when exposed to operating temperatures up to 480°F. An additional property of AURUM was its high tensile strength at room temperature and at 400°F."

Kodak's dimensional requirements for the metal insert specified a close tolerance flange thickness and a groove perpendicular to the direction of pressing on the body of the insert. Both of these features required machining after sintering which Alpha Sintered Metals performs in-house. Alpha selected a 400 ton multi-action press, a pure dry hydrogen atmosphere was selected for sintering so finish machine operations could be accomplished economically.

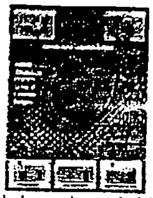
The original all-AURUM gudgeon, which was a direct replacement for a glass - filled thermoset polyimide, was molded by Pixley Richards on a 185 ton machine using AURUM processing conditions of 22,000 psi injection pressure barrel temperatures of 730°F - 770°F, and a mold temperature of 400°F.

These parts were made in the original thermoset mold tooling with minor modifications. Because the cavities were designed for a thermoset part, the product was not optimized to utilize the unique characteristics of AURUM.

The AURUM /metal composite gudgeon was developed to take advantage of these capabilities. Processing requirements were dramatically different due to the requirement of the stainless steel powdered metal insert, yet the AURUM was able to achieve the final needs of Kodak. Process pressures needed to be much lower (i.e., 7000 psi) to prevent damage or collapse of the stainless steel insert and melt temperatures needed to be elevated substantially to achieve the lower pressures while gaining good knit line strength and density. Ian MacLeod noted, "Although the process window was substantially narrowed, it is still a viable manufacturing process and will run in a trouble free manner. Few materials tolerate this range well".

Injection molded AURUM Thermoplastic Polyimide components are utilized in a variety of other demanding applications such as automotive transmission thrust washers, check

of **mechanical engagement** and **shrink fit**. The AURUM section, as in the all-AURUM gudgeon design, serves as a thermal barrier to minimize heat transfer to the bearing, and as a low friction and wear resistant surface at elevated temperatures.



(Click to enlarge) 117kb

balls, and oil seal rings; wear and friction components for business machinery, industrial compressors, appliances, and power tools; jet engine and aircraft components; high-performance gears; and high-purity components for semiconductor wafer and hard disk handling and manufacturing equipment. AURUM® is also extruded as a monofilament, thin-wall tubing, wire and cable insulation, and rod.

(View Dynamic Viscoelasticity Chart of Aurum) 48.7kb

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Exhibit 5

Webster's Third New International Dictionary

OF THE ENGLISH LANGUAGE

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bonce \ˈbän(t)s\ *n* -s [origin unknown] *dial Eng* : a boys' game played with marbles; *also* : a large marble
¹bond *n* -s [ME *bonde* peasant, serf, fr. OE *bōnda, bunda* householder, husband, fr. ON *bōndi*, alter. of *būandi*, fr. pres. part. of *būa* to live, dwell, have a household — more at BOWER] *obs* : BONDMAN
²bond *adj* [ME *bonde*, fr. *bonde*, n.] : being in a state of serfdom, servitude, or slavery : BOUND ⟨by one spirit are we all baptized into one body . . . whether we be ~ or free —1 Cor 12:13 (AV)⟩
³bond \ˈbänd\ *n* -s [ME *band, bond* — more at BAND] **1 a** : something that confines or restrains (as a fetter or chain) : SHACKLE — usu. used in pl. ⟨you may chain the law down with all manner of clamps and ~s —B.N.Cardozo⟩ **b** *archaic* : IMPRISONMENT, CONFINEMENT — usu. used in pl. **2** : an agreement binding one or more parties ⟨a ~ between two governments to aid each other in war⟩ : COVENANT, CHARTER ⟨the principles of friendship and ethics as espoused in the ~ of Phi Delta Theta —P.F.Connolly⟩ **3 a** : a hoop, band, or cord used to hold something down or together (as wheat, fagots, thatch) ⟨master the trick of tying the sheaf with its ~ —H.E.Bates⟩ **b** : a piece of building material (as a timber, brick, stone) that serves to bind or unite **c** : a device for binding together the armor or lead sheaths of two or more adjacent cables or for anchoring a cable to the earth **d** : a conductor that provides a continuous path for electric current between adjacent metal parts of a structure: as (1) : a conductor between the abutting rails of a track (2) : the connection between water mains and gas mains (3) : the grounded return of an electric railway system **e** : a mechanism by means of which atoms, ions, or groups of atoms are held together in a molecule or crystal, being usu. represented in chemical formulas by a line, a dot, or a pair of dots or lines denoting paired electrons — called also *link, linkage*; see COVALENT BOND, DOUBLE BOND, ELECTROSTATIC BOND, ELECTROVALENT BOND, HYDROGEN BOND, METALLIC BOND, TRIPLE BOND, VALENCE **f** : an adhesive that binds different ingredients together: as (1) : a cementing material that holds abrasive grains together (as in grinding wheels) or that binds the grains to the backing in coated abrasives (as sandpaper) (2) : the lime in silica brick (3) : a fusible ingredient that imparts strength to fired ceramic ware **4 a** : a uniting or binding element or force : TIE ⟨the ~ of fellowship⟩ — often used in pl. ⟨his wish to strengthen the ~s between Colombia and the U.S. —*Current Biog.*⟩; *specif* : a linkage between a stimulus and a reaction or between one idea and an associated idea ⟨the ~ theory of learning⟩ **b** : the state, result, or an instance of being bonded (as by an adhesive) : COHESION ⟨it is impossible to secure the proper ~ of coating to metal when the slightest particle of rust is present —*advt*⟩ **c** : resistance to slipping (as between the major components of a structure) provided by adhesion or friction ⟨precautions were taken to prevent ~ between the concrete roadway and the structural steel beneath it so that the concrete could shorten under the compression —N.J. Sollenberger⟩ **5 a** (1) : a writing under seal by which a person binds himself to pay a certain sum on or before an appointed day and usu. containing a condition that if the obligator shall do or abstain from doing a certain act on or before a time specified the obligation shall be void but otherwise shall remain in full force; *also* : the amount of money so guaranteed — often used with *give* ⟨each must give ~ for his appearance before the court⟩; compare BAIL, PENAL SUM (2) : one who acts as bail or surety **b** : an interest-bearing document giving evidence of a long-term debt and issued by a government body or corporation sometimes secured by a lien on property and often designed to take care of a particular financial need — see CALLABLE, COLLATERAL TRUST BOND, COUPON BOND, DEBENTURE, EQUIPMENT BOND, HIGHWAY BOND, REGISTERED BOND, SAVINGS BOND, SERIAL BOND, SINKING-FUND BOND, TAP BOND **c** : an insurance agreement pledging surety for financial loss caused to another by the act or default of a third person or by some contingency over which the third person may have no control **6** : a connection or system of connections in which adjacent parts of a structure are made to overlap so as to be tied or bound together; *specif* : the systematic lapping of brick in a wall ⟨the brickwork is unusually fine and the ~ used on the south front of the house is different from that on the other sides —*Amer. Guide Series: La.*⟩ — see AMERICAN BOND, BLIND BOND, BLOCK-IN-COURSE BOND, CHAIN BOND, CROSS-AND-ENGLISH BOND, CROSS BOND, DIAGONAL BOND, DOG'S-TOOTH BOND, ENGLISH BOND, ENGLISH CROSS BOND, FLEMISH BOND, FLYING BOND, HERRINGBONE BOND, IN-AND-OUT BOND, PLUMB BOND, RANGING BOND, RUNNING BOND, SPLIT BOND **7** : the state of goods being manufactured, stored, or transported under the care of bonded agencies until the duties or taxes on them are paid ⟨you may leave . . . tobacco in ~ with customs —Richard Joseph⟩ **8** : a 100-proof straight whiskey that has been aged at least four years under government supervision before being bottled — called also *bonded whiskey* **9** : BOND PAPER
⁴bond \ˈ"\ *vb* -ED/-ING/-S *vt* **1** : to bind or tie (a wall, a building, or various masonry units) usu. by lapping one unit over another **2** : to place under the conditions of a bond: as **a** : to secure the payment of the duties and taxes on (goods or merchandise being manufactured, warehoused, or transported) by giving a bond **b** : to mortgage or issue bonds secured by mortgage upon (property) **c** : to convert into a debt secured by bonds **d** : to give or secure an option upon (as a mine or other property) by a bond tying up the property till the option has expired **e** : to provide a bond (sense 5c) for or cause to provide such a bond ⟨~ a trustee⟩ ⟨~ an employee⟩ ⟨~ an official⟩ **3** : to bind together or connect by or as if by bonds: as **a** : to cause to adhere firmly (as metal to glass or plastic) **b** : to make secure and adequate electrical connection between (two or more conductors) either to ensure free passage of current ⟨a railroad track with ~*ed* joints⟩ or to maintain uniformity of electric potential (as of water and gas piping or the sheaths of electric cables) — compare ³BOND 3d **c** : to embed in a matrix ⟨abrasive material ~*ed* in a resinous binder to form a grinding wheel⟩ — compare ³BOND 3f **d** : to hold together in a molecule or crystal by means of chemical bonds ~ *vi* : to hold together or solidify by or as if by means of a bond or a binder ⟨a cement failing to make materials ~⟩; *specif* : to cohere (as the fibers in paper, the coating of the surface of paper, the elements in laminated board) ⟨the coatings ~ tightly to many surfaces —*Graphic Arts Monthly*⟩ — **bond·a·ble** \-dəbəl\ *adj*
bond·age \ˈbändij, -dēj\ *n* -s [ME, fr. ML *bondagium*, fr. ME *bonde* peasant, serf + L *-agium* -age] **1 a** : the tenure or service of a villein, serf, or slave **b** *chiefly Scot* : services due from a tenant farmer to his proprietor or from a cottager to the farmer **2** : the quality or state of being bound: **a** : restraint of personal liberty by compulsion : SERFDOM, CAPTIVITY ⟨the ~ of the Hebrews in Egypt⟩ **b** : voluntary subjugation (as to some service or duty) ⟨she had gone into ~ among the aristocracy as a governess —Virginia Woolf⟩ **c** : servitude or subjugation (as to someone superior or dominating or to some power, motive, or appetite) ⟨with the House of Representatives in ~ to its leaders —Lindsay Rogers⟩ ⟨the ~ of specialization⟩ ⟨the obvious and painful ~ of shyness —Helen Howe⟩ **d** *linguistics* : the state of being a bound form
bond·ag·er \-jə(r)\ *n* -s **1** : one that performs bondage service **2** *chiefly Scot* : one obligated to perform certain services on a farm; *specif* : a woman engaged by a tenant farmer or cotter under his agreement with the proprietor to do field work on the farm
bon·dar \ˈbän,där\ *n* -s [prob. fr. Bengali or Hindi *bãda* monkey — more at BANDAR] : a palm civet (*Paradoxurus hermaphrodytus*) of India
bond clay *n* [³*bond*] : a plastic ceramic clay that gives strength to dry but unfired ware
bond coat *n* [³*bond*] : a coat (as of plaster or paint) to ensure adhesion
bond course *n* [*bond*stone] : a course of masonry bondstones
bonded *adj* [fr. past part. of ⁴*bond*] : in, operating under, or placed under a bond ⟨a ~ carrier⟩ ⟨~ goods⟩
bonded debt *n* : that part of the indebtedness of a government or corporation represented by bonds — called also *funded debt*
bonded store *n*, *Brit* : BONDED WAREHOUSE
bonded warehouse *n* **1** : a warehouse under bond to the government for payment of customs duties and taxes on goods stored or processed there **2** : a warehouse insured against loss or damage to goods stored therein
bonded whiskey *n* : ³BOND 8
¹bon·der \ˈbändə(r)\ *n* -s [⁴*bond* + *-er*] **1** : one that bonds: as **a** : an assembler of electromagnet laminations **b** : a worker who welds copper bonds between the joints of rails **2** : BONDSTONE 1
²bond·er \ˈ"\ *n* -s [modif. of Norw *bonde* and Icel *bōndi* householder, fr. ON *bōndi* — more at BOND] : a Norwegian or Icelandic farmer or peasant landowner
bond·er·ize \ˈbändə,rīz\ *vt* -ED/-ING/-S [back-formation fr. *Bonderized*, a trademark] : to coat (steel) with a patented phosphate solution for protection against corrosion
bondholder \ˈ-,--\ *n* [³*bond* + *holder*] : a person who holds a bond (as of a government or corporation)
bon·dieu·se·rie \bōn,dyüzəˈrē\ *n* -s [F, fr. *bon Dieu* dear Lord (fr. *bon* good + *dieu* god, fr. L *deus*) + connective *-s-* + *-erie* -ery — more at BONNY, DEITY] : banal and often shoddy religious art; *also* : a piece of bondieuserie (as a statue or picture)
bonding *n* -s [fr. gerund of ⁴*bond*] : electrical interconnection between parts (as of an airplane) to minimize differences of voltage
bonding company *n* [fr. pres. part. of ⁴*bond*] : a company issuing fidelity and surety bonds : SURETY COMPANY
bonding course *n* : BOND COURSE

bombing pres part of BOMB

bombing run n : BOMB RUN

bomb ketch n : a small strongly built ... having mortars mounted for use in naval bombardment

bomb lance n : a harpoon with an explosive head

bomb-line \ˈ.,.\ n -s : a demarcation line established in a combat area beyond which aircraft can attack (as by bombing) without danger to their own ground troops

bomb-load \ˈ.,.\ n : the quantity of bombs carried by an aircraft and measured by weight, by number, or (as for nuclear bombs) by kilotons or megatons of equivalent TNT

bombo var of BUMBO

bom-bonne \ˈbäm,bän\ n -s [F, fr. Prov boumbouno, fr. boumbo large ball, fr. L bombus deep hollow sound — more at BOMB] : a large globular bottle; specif : an earthenware Woulff bottle

bomb out vt 1 : to subject (as an industrial center) to bombing so that continued operation or inhabitation of the bombed objective is impossible (a munitions factory which was bombed out early in the war) (a once beautiful city that was now bombed out) 2 : to force out of a dwelling or place of business by bombing : make homeless by bombing (millions of people were bombed out)

bomb plot n : a map or drawing of a bombed target annotated with the location of each bomb hit

¹bombproof \ˈ.,.\ adj : so constructed or placed as to be relatively secure against the explosive force of bombs or shells (a ~ cellar)

²bombproof \ˈ.,.\ n : a bombproof shelter

bomb release line n : the point on the ground ahead of the target over which an aircraft must release its bombs to get a hit on the target

bomb run n : the portion of a bomber's attack during which the actual sighting for and release of bombs occurs and which is flown usu. straight and level so that the bombardier's computations may be accurate

bombs pl of BOMB, pres 3d sing of BOMB

bomb-shell \ˈ.,.\ n 1 : BOMB 1 2 a : something that stuns, amazes, or is shatteringly upsetting: as (1) : a devastating surprise : a totally unexpected occurrence (her arrival was a ~ in the previously tranquil town) (2) : an unprecedented and often revolutionary idea or action (a new theory that was a ~ to conservative thinkers) b : one who is the cause and object of sensational and usu. widespread attention, excitement, or attraction (a writer who is a literary ~) (a film featuring a stunning actress who can best be described as a blond ~)

bombsight \ˈ.,.\ n : a sighting device for aiming bombs; specif : a combined optical aiming and calculating mechanism and gyroscopic control for dropping aerial bombs from high altitudes

bomb up vt : to load (an aircraft) with bombs (can be bombed up more or less like loading a clip of cartridges —Science News Letter) ~ vi : to take on a load of bombs

bom-bus \ˈbämbəs\ n, cap [NL, fr. L, deep hollow sound, buzzing — more at BOMB] : a genus of bees comprising the typical bumblebees — compare BOMBYLIIDAE

¹bom-by-cid \ˈbämbəsəd, -,sid\ adj [NL Bombycidae] : of or relating to the family Bombycidae or to silkworms

²bombycid \"\ n -s : one of the Bombycidae : a silkworm or silkworm moth

bom-byc-i-dae \bämˈbisə,dē\ n pl, cap [NL, fr. Bombyc-, Bombyx, type genus + -idae] : a family of chiefly Asiatic moderate-sized moths having larvae that feed on leaves and spin cocoons of commercially usable silk and including the domesticated silkworms (genus Bombyx) and a few related forms but formerly including many other moths

bom-by-cil-la \,bämbəˈsilə\ n, cap [NL, blend of L bombyc-, bombyx silkworm, silk and NL Motacilla — more at BOMBAST] : a genus (the type of the family Bombycillidae) of passerine birds comprising the waxwings

bom-by-cine \ˈbämbə,sīn, -,sēn\ adj [L bombyc-, bombyx silkworm + E -ine] : of or relating to silkworms

bom-by-li-i-dae \,bämbəˈlīə,dē\ n pl, cap [NL, fr. Bombylius, type genus (fr. Gk bombylios buzzing insect, bumblebee, fr. bombos deep hollow sound) + -idae — more at BOMB] : a family of hairy-bodied often brightly colored two-winged flies many of which resemble bees and are called bee flies

bom-byx \ˈbäm(,)biks\ n, cap [NL, fr. L, silkworm — more at BOMBAST] : the type genus of Bombycidae including the domestic silkworm moth (Bombyx mori) — see SILKWORM

¹bon \ˈbän\ n -s [perh. fr. D boon bean, fr. MD bōne; akin to OHG bōna bean — more at BEAN] 1 : BROAD BEAN 2 (perh. another word) : KIDNEY BEAN

²bon \ˈbōn\ n -s usu cap [Jap] : a great popular festival of Japan held July 13 to 16 when the spirits of ancestors are supposed to revisit the household altars — called also Feast of Lanterns

³bon \"\ n -s cap [Tibetan bön] : the pre-Buddhist animistic religion of Tibet

⁴bon \ˈbän\ n -s [origin unknown] : CHINA GRASS

bo-na \ˈbōnə\ n pl [L, fr. neut. pl. of bonus good] : PROPERTY — used in Roman and civil law of real and personal property of any kind but chiefly of real property in Roman law and usu. only of movables in common law

bona ad-ven-ti-tia or bona ad-ven-ti-cia \-,advənˈtish(ē)ə\ n pl [L bona adventicia adventitious goods] Roman Law : all the property that is acquired by a person by his own labor or from persons other than his father and which he is permitted to keep as his own subject to the right of his father to enjoy its usufruct — called also, in post-Roman times, peculium adventicium; compare BONA MATERNA

bo-na-ci \,bōnəˈsē\ n -s [Sp bonasí] : the black grouper (Mycteroperca bonaci) or a related marine food fish (as the gag)

bona con-fis-ca-ta \-,känfəˈskād-ə\ n pl [L, confiscated goods] : property (as that forfeited for felony) appropriated to the fiscus under Roman law

bona fide \ˈ+ˈbōnə,fīd, +ˈbänə,fīd, ...\ adj [L, in good faith] 1 : made in good faith without fraud or deceit (a bona fide contract) : legally valid (return of such persons to place of bona fide residence —U.S. Code) 2 : SINCERE (the only bona fide friends of democracy and self-determination —Sinclair Lewis) : made with earnest or wholehearted intent (a bona fide proposal) 3 : not specious or counterfeit : GENUINE (just what a bona fide United States flag looked like —E.J.Kahn) (bona fide dinosaur eggs) (bona fide pockets below the waistline —Women's Wear Daily) syn see AUTHENTIC

bona fide holder n : a holder of negotiable paper who before it reached maturity acquired title in the ordinary course of business and without actual or constructive notice of any defect in title or of lack of consideration

bona fide purchaser n : a purchaser who buys in good faith without notice of any defect and for a valuable consideration

bona fi-des \,..ˈfī,dēz, -fē,dās\ n [L] : good faith (a claimant whose bona fides is unquestionable) : lack of deceit or fraud (the bona fides of a transaction) : SINCERITY (lays himself open to suspicion as to his bona fides and as to his knowledge by his remarks —F.W.Rolfe)

bon-aght \ˈbänəkt\ n -s [IrGael buannacht, fr. buanna soldier] : a tax formerly imposed by Irish chieftains upon their people for the quartering of soldiers

bon-ail-ie \bəˈnālē\ n -s [ME (Scottish dialect), alter. (influenced by MF bon good) of MF bien aler parting felicitation, gift, or repast, fr. bien (fr. L bene, adv. of bonus good) + aler, fr. fem. of ale, past part. of aler to go — more at BOUNTY, ALLEY] Scot : a parting drink : STIRRUP CUP

bona ma-ter-na \,bōnəməˈtərnə\ n pl [L, maternal property] Roman law : all the property a son subject to paternal power acquires from his mother — compare BONA ADVENTITIA

bo-nang \bōˈnäŋ\ n -s [Jav] : a Javanese musical instrument consisting of a series of tuned gongs

bo-na no-ta-bi-lia \,bōnə,nōdəˈbilēə\ n pl [L, notable goods] obs : the goods of a deceased person held in a diocese other than his own at the time of his death that according to older English probate law required consideration by the courts if of or exceeding the value of five pounds

bo-nan-za \bəˈnanzə, bō-\ n -s often attrib [Sp, lit., calm, fair weather, prosperity, rich mine, fr. ML bonacia, alter. (influenced by L bonus good) of L malacia calm at sea, fr. Gk malakia, lit., softness — more at BOUNTY, MALACIA] 1 a : an exceptionally large and rich ore shoot or pocket in veins carrying gold and silver b : a mine having such an ore shoot or pocket; also : the yield of such a mine (a ~ worth milli...) 2 a : something that yields an often unexpectedly large ... (a ~ enterprise) (put the full resources of his studio behind the picture ... and achieved a box-office ~ —Al Hine) b : an extremely large amount (the ~ paid to foreign countries to help them keep out of debt) (a ~ of Socialist sympathy —Time) c : something excessively rich, lush, or rewarding (the ~ farms of the middle west —Lewis Mumford) (a ~ era) — in bonanza of a mine : producing heavily and profitably

bo-na-parte's gull \ˈbōnə,pärts-\ or bo-na-parte gull \-t-\ n, usu cap B [after C.L.J.L.Bonaparte †1857 Fr. naturalist in U.S.] : a No. American black-headed gull (Larus philadelphia) about the size of a pigeon

bonaparte's sandpiper n, usu cap B [after C.L.J.L.Bonaparte] : WHITE-RUMPED SANDPIPER

bonaparte's weasel n, usu cap B [after C.L.J.L.Bonaparte] : a small weasel (Mustela cicognanii) of northern No. America, slightly larger than a chipmunk, short-tailed, and chocolate-brown turning white in winter

bo-na-part-ism \ˈbōnə,pärd-,izəm, -pàd-, ... -är,tiz-, -ä,tiz-\ n -s usu cap [prob. fr. F bonapartisme, fr. Napoléon Bonaparte (Napoleon I) †1821 Fr. emperor + F -isme -ism] 1 : the policy of Bonaparte 2 : a policy advocating or supporting dictatorial rule by a popular leader who has ostensibly received a mandate from the people (it has been a socialist and Communist tradition to be wary of Bonapartism —Aneurin Bevan)

¹bo-na-part-ist \ˈ..,.əst\ n -s usu cap [prob. fr. F bonapartiste, fr. Bonaparte + F -iste -ist] : one attached to the policy or family of Bonaparte

²bonapartist \"\ adj, usu cap : of, relating to, or supporting Bonaparte or Bonapartism

bo-na per-i-tu-ra \,bōnə,perəˈtùrə\ n pl [L] law : perishable property

bo-na-ro-ba \,bōnəˈrōbə, ˌbän-\ n -s [It buona roba good material, good property, fr. buona (var. of buono, fem. of buono good, fr. L bonus) + roba property, material, of Gmc origin; akin to OHG roub booty, something stolen — more at BOUNTY, ROBE] : COURTESAN, PROSTITUTE

bo-na-sa \bōˈnāsə, -äsə\ n, cap [NL, prob. alter. of L bonasus aurochs; fr. the similarity of its characteristic drumming sound to the bellowing of a bull] : a genus of birds (family Tetraonidae) containing only the ruffed grouse

bo-na-sus \bōˈnāsəs\ n, pl bonasi \-,sī\ [L, fr. Gk bonasos, bonassos] archaic : WISENT

bona va-can-tia \,bōnəvəˈkansh(ē)ə\ n pl [L, ownerless goods] law : goods without an apparent owner (as shipwrecks or the property of an intestate with no next of kin)

bon-a-ven-ture \,bänəˈvenchə(r), ...\ also bonaventure mizzen n -s [prob. fr. It buonaventura good luck, fr. buona good + ventura luck, fortune, short for avventura, fr. L adventura — more at BONA-ROBA, ADVENTURE] : a sail hoisted on the fourth mast of a medieval boat; also : the mast itself

bon-a-vist \ˈbänəvəst, -,vist\ also bonavist bean n -s [prob. fr. It buona vista fine sight, fr. buona good + vista sight — more at VISTA] : HYACINTH BEAN

bona wa-vi-a-ta \,bōnə,wāvēˈād-ə\ n pl [ML, waived goods] : WAIFS

bon-bon \ˈbän,bän\ n -s [F, (baby talk), redupl. of bon good, fr. L bonus] 1 : a piece of candy; specif : a small chocolate-coated or fondant-covered candy with a center of sugar fondant to which fruits and nuts are sometimes added 2 : something cloying and insubstantial (newsstands ... plastered with gory thrillers, romantic ~s, and pornography —Michael Scully)

bon-bon-nière \,bänbəˈni(ə)r, ,bō"bonˈye(ə)(ə)r\ n -s [F, fr. bonbon] : a small fancy box or dish for bonbons

bonbon spoon n : a spoon with a flat perforated bowl for bonbons and nuts

bonce \ˈbän(t)s\ n -s [origin unknown] dial Eng : a boys' game played with marbles; also : a large marble

¹bond n -s [ME bonde peasant, serf, fr. OE bōnda, bunda householder, husband, fr. ON bōndi, alter. of bōandi, fr. pres. part. of būa to live, dwell, have a household — more at BOWER] obs : BONDMAN

²bond adj [ME bonde, fr. bonde, n.] : being in a state of serfdom, servitude, or slavery : BOUND (by one spirit are we all baptized into one body ... whether we be ~ or free —1 Cor 12:13 (AV))

³bond \ˈbänd\ n -s [ME band, bond — more at BAND] 1 a : something that confines or restrains (as a fetter or chain) : SHACKLE — usu. used in pl. (you may chain the law down with all manner of clamps and ~s —B.N.Cardozo) b archaic : IMPRISONMENT, CONFINEMENT — usu. used in pl. 2 : an agreement binding one or more parties (a ~ between two governments to aid each other in war) : COVENANT, CHARTER (the principles of friendship and ethics as expressed in the ~ of Phi Delta Theta —P.F.Connolly) 3 a : a hoop, band, or cord used to hold something down or together (as wheat, fagots, thatch) (master the trick of tying the sheaf with its ~ —H.E.Bates) b : a piece of building material (as a timber, brick, stone) that serves to bind or unite c : a device for binding together the armor or lead sheaths of two or more adjacent cables or for anchoring a cable to the earth d : a conductor that provides a continuous path for electric current between adjacent metal parts of a structure: as (1) : a conductor between the abutting rails of a track (2) : the connection between water mains and gas mains (3) : the grounded return of an electric railway system e : a mechanism by means of which atoms, ions, or groups of atoms are held together in a molecule or crystal, being usu. represented in chemical formulas by a line, a dot, or a pair of dots or lines denoting paired electrons — called also link, linkage; see COVALENT BOND, DOUBLE BOND, ELECTROSTATIC BOND, ELECTROVALENT BOND, HYDROGEN BOND, METALLIC BOND, TRIPLE BOND, VALENCE f : an adhesive that binds different ingredients together: as (1) : a cementing material that holds abrasive grains together (as in grinding wheels) or that binds the grains to the backing in coated abrasives (as sandpaper) (2) : the lime in silica brick (3) : a fusible ingredient that imparts strength to fired ceramic ware 4 a : a uniting or binding element or force : TIE (the ~s of fellowship) — often used in pl. (his wish to strengthen the ~s between Colombia and the U.S. —Current Biog.); specif : a linkage between a stimulus and a reaction or between one idea and an associated idea (the ~ theory of learning) b : the state, result, or an instance of being bonded (as by an adhesive) : COHESION (it is impossible to secure the proper ~ of coating to metal when the slightest particle of rust is present —advt) c : resistance to slipping (as between the major components of a structure) provided by adhesion or friction (precautions were taken to prevent ~ between the concrete roadway and the structural steel beneath it so that the concrete could shorten under the compression —N.J. Sollenberger) 5 a (1) : a writing under seal by which a person binds himself to pay a certain sum on or before an appointed day and use, containing a condition that if the obligator shall do or abstain from doing a certain act on or before a time specified the obligation shall be void but otherwise shall remain in full force; also : the amount of money so guaranteed — often used with give (each must give ~ for his appearance before the court); compare BAIL, PENAL SUM (2) : one who acts as bail or surety b : an interest-bearing document giving evidence of a long-term debt and issued by a government body or corporation sometimes secured by a lien on property and often designed to take care of a particular financial need — see CALLABLE, COLLATERAL TRUST BOND, COUPON BOND, DEBENTURE, EQUIPMENT BOND, HIGHWAY BOND, REGISTERED BOND, SAVINGS BOND, SERIAL BOND, SINKING-FUND BOND, TAP BOND c : an insurance agreement pledging surety for financial loss caused to another by the act or default of a third person or by some contingency over which the third person may have no control 6 : a connection or system of connections in which adjacent parts of a structure are made to overlap so as to be tied or bound together; specif : the systematic lapping of brick in a wall (the brickwork is unusually fine and the ~ used on the south front of the house is different from that on the other sides —Amer. Guide Series: La.) — see AMERICAN BOND, BLIND BOND, BLOCK-IN-COURSE BOND, CHAIN BOND, CROSS-AND-ENGLISH BOND, CROSS BOND, DIAGONAL BOND, DOG'S-TOOTH ENGLISH BOND, ENGLISH CROSS BOND, FLEMISH BOND, ...NG BOND, HERRINGBONE BOND, IN-AND-OUT BOND, PLUMB BOND, RANGING BOND, RUNNING BOND, SPLIT BOND 7 : the state of goods being manufactured, stored, or transported under the care of bonded agencies until the duties or taxes on them are paid (you may leave ... tobacco in ~ with customs —Richard Joseph) 8 : a 100-proof straight whiskey that has been aged at least four years under government supervision before being bottled — called also bonded whiskey 9 : BOND PAPER

⁴bond \"\ vb -ED/-ING/-S vt 1 : to bind or tie (a wall, a building, or various masonry units) usu. by lapping one unit over another 2 : to place under the conditions of a bond: as a : to secure the payment of the duties and taxes on (goods or merchandise being manufactured, warehoused, or transported) by giving a bond b : to mortgage or issue bonds secured by mortgage upon (property) c : to convert into a debt secured by bonds d : to give or secure an option upon (as a mine or other property) by a bond tying up the property till the option has expired e : to provide a bond (sense 5c) for or cause to provide such a bond (~ a trustee) (~ an employee) (~ an official) 3 : to bind together or connect by or as if by bonds: as a : to cause to adhere firmly (as metal to glass or plastic) b : to make secure and adequate electrical connection between ~~two or more conductors) usu. to insure free passage of current (a railroad track with ~ed joints) or to maintain uniformity of electric potential~~ (as of water and gas piping or the sheaths of electric cables) — compare ³BOND 3d c : to embed in a matrix (abrasive material ~ed in a resinous binder to form a grinding wheel) — compare ³BOND 3f d : to hold together in a molecule or crystal by means of chemical bonds ~ vi : to hold together or solidify by or as if by means of a bond or a binder (a cement failing to make materials ~); specif : to cohere (as the fibers in paper, the coating of the surface of paper, the elements in laminated board) (the coatings ~ tightly to many surfaces —Graphic Arts Monthly) — bond-a-ble \-dəbəl\ adj

bond-age \ˈbändij, -dēj\ n -s [ME, fr. ML bondagium, fr. ME bonde peasant, serf + L -agium -age] 1 a : the tenure of service of a villein, serf, or slave b chiefly Scot : services due from a tenant farmer to his proprietor or from a cottager to the farmer 2 : the quality or state of being bound: a : restraint of personal liberty by compulsion : SERFDOM, CAPTIVITY (the ~ of the Hebrews in Egypt) b : voluntary subjugation (as to some service or duty) (she had gone into ~ among the aristocracy as a governess —Virginia Woolf) c : servitude or subjugation (as to someone superior or dominating or to some power, motive, or appetite) (with the House of Representatives in ~ to its leaders —Lindsay Rogers) (the ~ of specialization) (the obvious and painful ~ of shyness —Helen Howe) d linguistics : the state of being a bound form

bond-ag-er \-jə(r)\ n -s 1 : one that performs bondage service 2 chiefly Scot : one obligated to perform certain services on a farm; specif : a woman engaged by a tenant farmer or cotter under his agreement with the proprietor to do field work on the farm

bon-dar \ˈbän,där\ n -s [prob. fr. Bengali or Hindi bāndar monkey — more at BANDAR] : a palm civet (Paradoxurus hermaphroditus) of India

bond clay n [³bond] : a plastic ceramic clay that gives strength to dry but unfired ware

bond coat n [³bond] : a coat (as of plaster or paint) to ensure adhesion

bond course n [bondstone] : a course of masonry bondstones

bonded adj [fr. past part. of ⁴bond] : in, operating under, or placed under a bond (a ~ carrier) (~ goods)

bonded debt n : that part of the indebtedness of a government or corporation represented by bonds — called also funded debt

bonded store n, Brit : BONDED WAREHOUSE

bonded warehouse n 1 : a warehouse under bond to the government for payment of customs duties and taxes on goods stored or processed there 2 : a warehouse insured against loss or damage to goods stored therein

bonded whiskey n : ³BOND 8

¹bon-der \ˈbändə(r)\ n -s [⁴bond + -er] 1 : one that bonds: as a : an assembler of electromagnet laminations b : a worker who welds copper bonds between the joints of rails 2 : BONDSTONE 1

²bond-er \"\ n -s [modif. of Norw bonde and Icel bōndi householder, fr. ON bōndi — more at BOND] : a Norwegian or Icelandic farmer or peasant landowner

bond-er-ize \ˈbändə,rīz\ vt -ED/-ING/-S [back-formation fr. Bonderized, a trademark] : to coat (steel) with a patented phosphate solution for protection against corrosion

bondholder \ˈ.,..\ n [³bond + holder] : a person who holds a bond (as of a government or corporation)

bon-dieu-se-rie \bōn,dyǣzəˈrē\ n -s [F, fr. bon Dieu dear Lord (fr. bon good + dieu god, fr. L deus) + connective -s- + -erie -ery — more at BONNY, DEITY] : banal and often shoddy religious art; also : a piece of bondieuserie (as a statue or picture)

bonding n -s [fr. gerund of ⁴bond] : electrical interconnection between parts (as of an airplane) to minimize differences of voltage

bonding company n [fr. pres. part. of ⁴bond] : a company issuing fidelity and surety bonds : SURETY COMPANY

bonding course n : BOND COURSE

bonding plaster n : BOND PLASTER

bond-less \ˈbändləs, rapid -nl-\ adj : being without a bond

bond-maid \ˈbän(d),mād\ n, archaic : a female slave or bond servant

bond-man \ˈbän(d)mən\ n, pl bondmen [ME bondeman peasant, serf, fr. bonde peasant, serf + man — more at BOND] : one who is bound : SLAVE, SERF, VILLEIN

bond miner n [³bond] : a contractor hewer

bon-do \ˈbän(,)dō\ n, pl bondo or bondos usu cap 1 : a people of the hill country of the Koraput district in India 2 : a member of the Bondo people

bond of indemnity [³bond] : an indemnification agreement filed with a carrier relieving it from liability for something that it would otherwise be liable for

bon-don \(ˈ)bō"ˌdō"\ also bondon cheese n -s [F bondon, lit., bung, fr. bonde bung, fr. (assumed) Gaulish bunda; akin to MIr bond, bonn sole of the foot, L fundus bottom — more at BOTTOM] : a cheese resembling a bung in form and made in Neufchâtel, France

bond paper n [³bond] : a strong durable paper of a type orig. made for documents (as government bonds) and now commonly used for letterheads and other stationery

bond plaster n [³bond] : a plaster with high adhesive properties made esp. for use as a first coat on interior concrete surfaces

bonds pl of BOND, pres 3d sing of BOND

bondslave \ˈ.,.\ n [²bond + slave] : a person in slavery : BONDMAN, SLAVE

¹bonds-man \ˈbän(d)zmən\ n, pl bondsmen [by alter.] : ¹BONDMAN

²bonds-man \"\ n, pl bondsmen [³bond + -s + man] : one who assumes the responsibility of a bond : SURETY

³bondsman \"\ n, pl bondsmen usu cap [Afrik, fr. Bond (short for Afrikanerbond, lit., alliance of Afrikaners, fr. Afrikaner + bond alliance, fr. MD, bundle, alliance) + man, fr. MD; akin to OE bundel bundle and to OE man, mon man — more at BUNDLE, MAN] : a member of the Afrikanerbond, an organization founded in 1880 to achieve unification and independence of the states and colonies of So. Africa

bondstone \ˈbän,stōn\ n [³bond + stone] 1 : a stone running through a masonry wall to bind it together 2 : a stone that joins the coping above a gable to the upper surface of a wall

bond timber n [³bond] : a timber built horizontally into a masonry wall to which battens and laths are fastened — compare CHAIN BOND

bon-duc \ˈbän,dək\ n -s [F, fr. Ar bunduq hazelnut, filbert] 1 : NICKER NUT 2 also bonduc tree : any of several trees of the genus Caesalpinia (as C. bonduc) with large prickly pods enclosing beanlike seeds 3 : KENTUCKY COFFEE TREE

bond-wom-an \ˈbän,dwu̇mən\ also bonds-wom-an \-n(d)z-\ n, pl bondwom-en also bondswom-en \-wimən\ [ME bondewoman, fr. bonde bond (adj.) + woman — more at BOND] : a female slave

REISSUE LITIGATION
Raymond Degner et al.
Reissue Appln. 10/734,073 Filed Dec. 12, 2003
For: COMPOSITE ELECTRODE FOR PLASMA
Protester: Xycarb Ceramics, Inc.
Attorney Docket: 01-9665-06.4 Attorney: John E. Wagner
(818) 957-3340

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ATTACHMENT II

June 30

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Attorneys for LAM RESEARCH CORPORATION

UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

SAN FRANCISCO DIVISION

LAM RESEARCH CORPORATION,

Plaintiff,

v.

SCHUNK SEMICONDUCTOR and XYCARB CERAMICS, INC.,

Defendants.

Pleading Clip

Case No. C 03-01335 CRB

LAM RESEARCH CORPORATION'S REPLY BRIEF IN SUPPORT OF APPLICATION FOR TEMPORARY RESTRAINING ORDER TO ENJOIN XYCARB CERAMICS, INC. FROM INFRINGING PATENT '456

Date: July 3, 2003
Time: 10:00 a.m.
Place: Courtroom 8, 19th Floor
Judge: The Hon. Charles R. Breyer

Date Complaint Filed: March 27, 2003

3. <u>The Use of Shrink Fit Bonding in the Xycarb Electrode Infringes the '456 Patent</u>

Relying on so-called experts with only chemistry backgrounds, Xycarb concludes that "bonding requires an adhesive" and that a "shrink-fit" is "not a bond of any type". [Epstein Decl. ¶¶11-12] Neither of these "experts" are skilled in the art of the '456 Patent and their conclusions are entirely unqualified[4] and wrong. As explained in the Declarations of Mr. Hashemi (¶¶4-7) and Mr. Lenz (¶7), a mechanical engineer (which is the type of engineer skilled in the art of the '456 Patent) would not limit the term "bonding" to the attachment of two materials by an adhesive. In mechanical engineering design, bonding can be accomplished in a variety of ways and one common method is a "shrink fit" (a.k.a. "press fit" or "interference fit") as is used in the assembly of the Xycarb Electrode.

That a "shrink fit" is a method of bonding is further evidenced by various publications, which specifically refer to a "shrink fit" as a bonding method. Some examples (attached to the Supp. Michael Decl., Exs. 1-4) follow: (1) "***bonding means can take the form of a shrink fit***" [U.S. Patent No. 4,385,979 at 13:68 – 14:8]; (2) piston comprised by "***shrink fit bonding***" [U.S. Patent No. 5,014,604 at 2:43-45 and 3:26-28]; (3) "second preferred method of bonding . . . comprises a ***shrink fit bonding*** method." [U.S. Patent No. 6,419,806 at 6:14-16], and (4) "***[a] press fit joint represents a bond*** between two parts." [Investigation of The Press Fit Joints By the Tribology Aspect, at p.1].[5]

Further, Xycarb inaccurately states that the '456 Patent does not disclose a "shrink fit" as a method of creating the bond between the electrode plate and support ring. Again, such a specific disclosure is not necessary, but the reality is that dependent Claim 32 expressly discloses what any mechanical engineer would understand to be a "shrink fit":

> An electrode assembly as in claim 18, wherein the support ring is pre-stressed to impart a radially inward compression on the electrode disk.

[Supp. Lenz Decl., ¶8; Hashemi Decl., ¶11] Xycarb admits that bond between the electrode plate and

---

[4] The incredibility of Mr. Epstein's testimony is further evidenced by his own resume, which consistently refers to "adhesive bonding", including a publication titled "Adhesive Bonding of Metals". If "bonding requires the use of an adhesive material," as Mr. Epstein declares, one must ask why Mr. Epstein modifies the term "bonding" with "adhesive" in his resume and the title of his publications.

[5] Even the definition of "bond" in a basic reference, such as Webster's, is not limited to an "adhesive." Definitions include: (a) "resistance to slipping (as between the major components of a structure) provided by adhesion *or* friction"; (b) "to make secure and adequate electrical connection between two or more either to ensure free passage of current [ ] or to maintain the uniformity of electric potential." [Michael Decl., Exh. 5]

support ring are created by the "shrink-fit alone". If true, and even in the absence of a bonding agent, Xycarb's use of a "shrink-fit" as a method for creating a bond between the electrode plate and support ring literally infringes the '456 Patent

C. Xycarb's Red Herrings

Xycarb makes a number of irrelevant arguments that are briefly addressed here:

1. Xycarb's claims regarding infringement discussions in 2002 and all discussions regarding Lam's '577 Patent are irrelevant. Those infringement discussions, and Lam's infringement analysis, were based on Xycarb's international sales and Lam's international patent protection, primarily under Lam's '577 patent. [Supp. Brandt Decl., ¶¶1-3] Lam was not aware in 2002 that Xycarb had penetrated the U.S. market where Xycarb would be subject to infringement of the '456 Patent. [Supp. Brandt Decl., ¶4]

2. Xycarb's international PCT application is entirely irrelevant. One of the most important principles of international patent law is the "independence of patents", which provides "[p]atents applied for in the various countries... shall be independent of patents obtained for the same invention in other countries...." [Paris Convention for the Protection of Industrial Property Article 4bis(1)] This standard is based on the recognition that the laws, administrative practice and jurisprudence governing patents differ from country to country. Inventions that qualify for a patent according to Dutch law may be different from that those that qualify for patenting according to British, German or United States law. Accordingly, findings in one country (whether by the court or patent examiner) have no influence or precedential value in another country. See *Heidelberger Druckmaschinen v. Hatscho Commercial Products, Inc.*, 21 F.3d 1068, 1072 n. 2 (Fed. Cir. 1994), ("international uniformity in theory and practice has not been achieved."); *Timely Products Corp. v. Arron*, 523 F.2d 288, 295 (2d Cir. 1975) (rejecting patentee's attempt to introduce foreign patents as evidence that the patentee's invention was not obvious).

3. Xycarb constantly refers to comparisons between the Xycarb Electrode and the Lam Electrode. The design of the Lam Electrode is wholly irrelevant to the question of whether Xcyarb is infringing the '456 Patent. The only relevant question is whether the Xycarb Electrode includes the elements of Claim 18 of the '456 Patent.

Xycarb also admits other facts establishing that the irreparable harm to Lam is even greater than Lam initially believed. First, Lam estimated that its annual revenues from sales of the Lam Electrode to IBM account for $1.2 - $1.4 million. [Maddock Decl. ¶7]. Xycarb, however, places its "loss of direct business for LAM replacement parts [at] as much as US $7 million on a yearly basis." [Paulus Decl. ¶11]. Since IBM alone cannot account for $7 million alone, Xycarb must be preparing to sell the infringing Xycarb Electrode to Lam customers other than IBM. Second, Xycarb performed the PL testing on both an 8" model ***and*** a 6" model [Michorius Decl. Exh. F at p. 2], apparently of identical configuration. It appears that Xycarb is attempting, and poised, to take over a substantial share of Lam U.S. customer base and market share as to ***both*** 8" and 6" electrodes. This threat is the exact reason why Lam enforces its statutory right to exclude and has not, and does not, license the '456 Patent. The threatened harm here is textbook irreparable harm and that harm is imminent.

Xycarb also attempts to establish that a TRO will harm Xycarb. However, yet again, Xycarb's own evidence defeats the finding of any such harm and confirms that a TRO will simply maintain the *status quo*. Xycarb states that it is "in competition for that contract" with IBM. [Smith Decl. at ¶ 6]. Xycarb also states that it is "now preparing to start regular supplies" of the Xycarb Electrode. [Van Den Cruijsem Decl., ¶29] Thus, Xycarb has not yet sold or supplied the Xycarb Electrode. As a result, issuing a TRO will preserve the *status quo*. Equally important, it will avoid the undeniable irreparable harm to Lam and the unavoidable business interruptions that will result if Xycarb is permitted to "start regular supplies" and customers begin integrating the infringing Xycarb Electrode into their multi-million dollar wafer fabrication systems.

IV. CONCLUSION

For the above reasons, Lam respectfully requests that this Court enter an order restraining Xycarb from making, using, selling or offering to sell any products that infringe the '456 Patent.

DATED: June 30, 2003

Respectfully submitted,

NIXON PEABODY LLP

By: ______________________
Glenn E. Westreich
Attorneys for Plaintiff LAM RESEARCH CORPORATION

REISSUE LITIGATION
Raymond Degner et al.
Reissue Appln. 10/734,073 Filed Dec. 12, 2003
For: COMPOSITE ELECTRODE FOR PLASMA
Protester: Xycarb Ceramics, Inc.
Attorney Docket: 01-9665-06.4 Attorney: John E. Wagner
(818) 957-3340

ATTACHMENT III

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UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

SAN FRANCISCO DIVISION

LAM RESEARCH CORPORATION,

Plaintiff,

v.

SCHUNK SEMICONDUCTOR and XYCARB CERAMICS, INC.,

Defendants.

Case No. C 03-01335 CRB

LAM RESEARCH CORPORATION'S APPLICATION FOR TEMPORARY RESTRAINING ORDER TO ENJOIN XYCARB CERAMICS, INC. FROM INFRINGING PATENT '456

Date: June 20, 2003
Time: 10:00 a.m.
Place: Courtroom 8, 19th Floor
Judge: The Hon. Charles R. Breyer

Date Complaint Filed: March 27, 2003

MEMORANDUM OF POINTS AND AUTHORITIES

I. INTRODUCTION AND SUMMARY OF ARGUMENT

Lam, a designer and manufacturer of semiconductor processing equipment, seeks this temporary restraining order and order to show cause re preliminary injunction to prevent Xycarb from making, using, offering to sell or selling an electrode assembly (the "Xycarb Electrode") that infringes Lam's intellectual property rights embodied in Lam's U.S. Patent No. 5,074,456 (the '456 Patent). [Lenz Decl., Exh. A]

On Tuesday, June 17, 2003, International Business Machines Corporation ("IBM"), one of Lam's major customers, told Lam that it intends to stop ordering the Lam supplied electrode assembly embodied in the '456 Patent (the "Lam Electrode") and replace the Lam Electrode with the Xycarb Electrode. [Maddock Decl., ¶¶ 3-6] To Lam's knowledge, IBM is the first Lam customer in the U.S. to switch from the Lam Electrode in favor of the infringing Xycarb Electrode [Goodrich Decl., ¶4] – but it will not be the last if Xycarb's infringing activities are permitted to continue.

As demonstrated more fully below, Lam will succeed on the merits of its infringement claim. [See Section III.B.1 below, and Lenz Decl. at ¶¶ 13-22] In prior communications, Xycarb has implicitly acknowledged that the Xycarb Electrode is comprised, as specifically described in Claim 18 of the '456 Patent, of two-pieces: (1) an electrode plate composed of substantially pure material (in the Xycarb Electrode, silicon) and (2) a support ring composed of electrically and thermally conductive material (in the Xycarb Electrode, graphite). The sole defense Xycarb has asserted is that these two-pieces are not bonded as claimed by the '456 Patent because the Xycarb Electrode does "not include any indium or other bonding agent." Xycarb's assertion is both false and misguided.

With respect to Xycarb's assertion that its electrode includes no bonding agent, an independent lab report confirms the presence of a bonding agent between the electrode plate and support ring of the Xycarb Electrode -- an ***"epoxy acrylate material."*** [Kendall Decl., ¶5, Ex. A] Further, the specification of the '456 Patent discloses that the "support ring may be bonded to the electrode plate ***by any suitable process***". ['456 Patent at 3:64-67] This includes a chemical bond (such as an epoxy) as well as a mechanical bond (such as an interference fit), which Xycarb contends

is present in the Xycarb Electrode. Xycarb cannot escape the fact that the Xycarb Electrode satisfies every element of Claim 18 of the '456 Patent.

II. FACTUAL BACKGROUND

A. The '456 Patent

The '456 Patent, which was issued on December 24, 1991, claims a two-piece electrode assembly utilized in parallel plasma etch[1] systems comprised of:

(1) an electrode plate composed of substantially pure material (such as silicon), usually in the shape of a disk, with a substantially uniform thickness throughout, and

(2) a support ring composed of an electrically and thermally conductive material (such as graphite), to which one face of the plate is bonded leaving the other side of the plate flat and free from protuberances.

[Claim 18 of '456 Patent] "The support ring may be bonded to the electrode plate by any suitable process which provides the necessary bonding strength as well as thermal and electrical characteristics." ['456 Patent, 5:64-67]

B. The Infringing Xycarb Electrode

Although Lam enforces its statutory right to exclude others from the practice of the invention, and *does not license the technology of the '456 Patent* [Brandt Decl., ¶4], this has not stopped Xycarb from attempting to make inroads into Lam's customer base. Xycarb offers various replacement parts for the components and sub-assemblies of Lam's wafer fabrication systems, including the Xycarb Electrode which infringes the '456 Patent. To date, Xycarb has asserted non-infringement based on the sole ground that "the Xycarb electrodes do not include any indium or other bonding agent as claimed in the '456 patent." [Brandt Decl., Ex. A] Xycarb's claimed lack of a "bonding agent" in the Xycarb Electrode has proven false.

In February, 2003, Lam first obtained an infringing Xycarb Electrode. Based on a visual inspection only, Eric Lenz, a Lam employee and co-inventor of the '456 Patent, determined that the

[1] "Etch" generally refers to the process of selectively removing, by plasma or liquid chemicals, unneeded material from the wafer surface.

Sun Microsystems, Inc. v. Microsoft Corp., 188 F.3d 1115, 1999 (9th Cir. 1999) Regardless of the formulation, each of the four factors weighs in favor of granting a temporary restraining order.

B. Lam is Likely to Succeed On the Merits

1. Literal Infringement of Claim 18 the '456 Patent

The grant of a restraining order or preliminary injunction does not require that infringement "be proved beyond all question, or that there be no evidence supporting the viewpoint of the accused infringer." *H.H. Robertson Co. v. United Steel Deck*, 820 F.2d 384, 390 (Fed. Cir. 1987). Rather, Lam need only demonstrate a reasonable likelihood of success on the infringement of one patent claim. *Hybritech Inc. v. Abbott Laboratories*, 849 F.2d 1446, 1453-1454 (Fed. Cir. 1988). An element-by-element infringement analysis of Claim 18 of the '456 Patent clearly demonstrates Xycarb's infringement here. [Lenz Decl. ¶¶ 13-23]

Preamble: An electrode assembly comprising:

The Preamble of Claim 18 is obviously present in the Xycarb Electrode as it is an electrode assembly. [Lenz Decl. ¶ 16]

Element 1: an electrode composed of a substantially pure material and having a substantially uniform thickness; and

The first element of Claim 18 is also present in the Xycarb Electrode. The Xycarb Electrode has an electrode plate, with thickness that is substantially uniform across its surface. The ERI Report confirms that the electrode plate is composed of silicon which is substantially pure. [Lenz Decl., ¶ 17(b), 18(a)-(b) and Exh. C].

Element 2: a support ring bonded about the periphery of one face of the disk, leaving the other face substantially flat and free from protuberances, wherein the support ring is composed of an electrically and thermally conductive material.

The second element of Claim 18 is present in the Xycarb Electrode. The Xycarb Electrode includes a ring-shaped support component for supporting the electrode plate and the electrode plate is in the form of a disk. [Lenz Decl. ¶ 20(a)] The ring-shaped support in the Xycarb Electrode is bonded to one face of the electrode disk about a peripheral portion of the face and the Evans' 2/14/03 Report confirms a chemical bond by an "epoxy acrylate material". [Lenz Decl. ¶ 20(a), Exh. B] Additionally, the face of the electrode disk, opposite the face to which the ring-shaped support is

bonded, is substantially flat and includes no protuberances. [Lenz Decl. ¶ 20(b)] The Evans' 6/9/03 Report confirms that the ring-shaped support is composed of graphite, which is electrically and thermally conductive. [Lenz Decl. ¶ 20(c), Exh. D]

Even assuming, as Xycarb claims, that the Xycarb Electrode does not include "indium or other bonding agent", the Xycarb Electrode still literally infringes Claim 18 of the '456 Patent. A claim must be construed in light of the specifications of the patent. *United States v. Adams*, 383 U.S. 39, 49 (1966). The specification of the '456 Patent reads:

> "The support ring may be bonded to the electrode plate ***by any suitable process*** which provides the necessary bonding strength as well as thermal and electrical characteristics. ***Typically***, bonding will be performed by either brazing, soldering or use of adhesives to form a ductile bonding layer."

['456 Patent, 5:64 – 6:1] (emphasis added)

This language from the specification makes clear that the term "bonded" is entitled to a broad interpretation that includes, but is not limited to, a bonding agent. While a "typical" bonding process will include brazing, soldering or use of adhesives to form a ductile bonding layer, such a process is not required. Rather, the specification expressly recognizes that the ring may be bonded to the plate "by any suitable process".[3] Such a suitable process may include a chemical bond (i.e. such as the use of an epoxy adhesive), or a mechanical bond (such as an interference fit), or a combination of both, as long as the bond provides the "necessary bonding strength as well as thermal and electrical characteristics." [Lenz Decl., ¶21] In asserting that electrode plate and support ring of the Xycarb Electrode are bonded by an interference fit, Xycarb merely asserts (indeed, admits) the existence of a "suitable process" for bonding as claimed by the '456 Patent. [Lenz Decl., ¶21(b)-(c)] Thus, regardless of how Xycarb attempts to characterize its "bonding" technique, the Xycarb Electrode is precisely the invention embodied by Claim 18 of the '456 Patent.

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[3] This is further supported under the doctrine of claim differentiation. "Where some claims are broad and others narrow, the narrow claim limitations cannot be read into the broad whether to avoid invalidity or to escape infringement." *Kalman v. Kimberly-Clark Corp.*, 713 F.2d 760, 770 (Fed. Cir. 1983) (citations omitted). Here, Claim 24 limits the process of bonding the disk to the ring "by means of a bonding layer"; Claim 25 further limits the "bonding layer" to one "composed of a ductile metal or alloy or a metal-filled epoxy"; Claim 26 further limits the "ductile metal or alloy" to "indium, silver and metal-filled epoxies", and, finally; Claim 27 limits the "bonding layer" to one "formed by brazing, soldering, or adhesion." Xycarb's asserted defense of no indium or bonding agent seems more properly directed to these narrower, dependent claims. However, the limitations of those claims cannot be read into the broad use of the term "bonded" in Claim 18 as a basis for Xycarb to escape infringement.

interest cannot justify the denial of an injunction in a patent infringement lawsuit. Indeed, were lower prices "to be a justification for patent infringement, most injunctions would be denied because copiers [like Xycarb] universally price their products lower than innovators [like Lam]." *Payless Shoesource Inc. v. Reebok Int'l Ltd.*, 998 F.2d 985, 991 (Fed. Cir. 1993). The public interest is best served here by granting an injunction, as it will encourage innovation and protect the enforcement of patent rights.

IV. CONCLUSION

For the above reasons, Lam respectfully requests that this Court enter an order restraining Xycarb from making, using, selling or offering to sell any products that infringe the '456 Patent.

DATED: June 19, 2003

Respectfully submitted,

NIXON PEABODY LLP

By: [signature]

Glenn E. Westreich
Attorneys for Plaintiff LAM RESEARCH CORPORATION

PROOF OF SERVICE

I, the undersigned, certify that I am a patent agent associated with the LAW OFFICES OF JOHN E. WAGNER; that I am over eighteen years of age and not a party to the within action; and that my business address is KM ASSOCIATES, 2001 Jefferson Davis Highway, Suite 312, Arlington, VA 22202.

I served the following documents:

1. This transmittal letter with Deposit Account Authorization
2. Power of Attorney
3. Protest Under CFR 1.291(a) (6 pages)
4. Information Disclosure Statement (1 page)

Ref. A	4,385,979	Pierce et al.
Ref. B	publication	McGuire (excerpts)
Ref. C	4,564,435	Wickersham
Ref. D	4,931,135	Horiuchi
Ref. E	4,820,371	Rose
Ref. F	4,904,621	Loewenstein
Ref. G	4,367,114	Steinberg
Ref. H	4,297,162	Mundt
Ref. I	4,963,713	Horiuchi
Ref. J	4,792,378	Rose
Ref. K	4,544,091	Hidler

5. Copies of Refs. A-K on the Information Disclosure Statement above
6. Attachments I, II, and III from Case 3:03-cv-01335 Northern District of California
7. Declaration of JW verifying authenticity of Attachments I, II, III, and IV
8. Attachment I
   SUPPLEMENTAL DECLARATION OF PATRICK MICHAEL IN SUPPORT OF LAM RESEARCH CORPORATION'S APPLICATION FOR TEMPORARY RESTRAINING ORDER
9. Attachment II
   LAM RESEARCH CORPORATION'S REPLY BRIEF IN SUPPORT OF APPLICATION FOR TEMPORARY RESTRAINING ORDER TO ENJOIN XYCARB CERAMICS FROM INFRINGING PATENT '456
10. Attachment III
    LAM RESEARCH CORPORATION'S APPLICATION FOR TEMPORARY RESTRAINING ORDER TO ENJOIN XYCARB CERAMICS, INC. FROM INFRINGING PATENT '456
    Attachment IV
    McGraw Hill SCIENTIFIC DICTIONARY
11. Listing of CLAIM COMPARISON SHEETS
12. CLAIM COMPARISON SHEETS (57 sheets)
13. Proof of Service on Opposing Counsel

on the parties stated below, through their attorneys of record, by placing a true copy thereof in a sealed envelope addressed as shown below by the following means of service:

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Alexandria, VA 22315-1404

I declare under penalty of perjury that the foregoing is true and correct. Executed on

May 10, 2004, at Arlington, VA.

Dennis Kreps
Dennis Kreps

I:\Lit\Xycarb\Lam\06.4.PROOF OF SERVICE

REISSUE LITIGATION
Raymond Degner et al.
Reissue Appln. 10/734,073 Filed Dec. 12, 2003
For: COMPOSITE ELECTRODE FOR PLASMA
Protester: Xycarb Ceramics, Inc.
Attorney Docket: 01-9665-06.4 Attorney: John E. Wagner
(818) 957-3340

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ATTACHMENT IV

McGraw-Hill DICTIONARY OF SCIENTIFIC AND TECHNICAL TERMS

Third Edition

SYBIL P. PARKER Editor in Chief

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In addition, material has been drawn from the following references: R. E. Huschke, *Glossary of Meteorology*, American Meteorological Society, 1959; *U.S. Air Force Glossary of Standardized Terms*, AF Manual 11-1, vol. 1, 1972; *Communications-Electronics Terminology*, AF Manual 11-1, vol. 3, 1970; W. H. Allen, ed., *Dictionary of Technical Terms for Aerospace Use*, 1st ed., National Aeronautics and Space Administration, 1965; J. M. Gilliland, *Solar-Terrestrial Physics: A Glossary of Terms and Abbreviations*, Royal Aircraft Establishment Technical Report 67158, 1967; *Glossary of Air Traffic Control Terms*, Federal Aviation Agency; *A Glossary of Range Terminology, White Sands Missile Range, New Mexico*, National Bureau of Standards, AD 467-424; *A DOD Glossary of Mapping, Charting and Geodetic Terms*, 1st ed., Department of Defense, 1967; P. W. Thrush, comp. and ed., *A Dictionary of Mining, Mineral, and Related Terms*, Bureau of Mines, 1968; *Nuclear Terms: A Glossary*, 2d ed., Atomic Energy Commission; F. Casey, ed., *Compilation of Terms in Information Sciences Technology*, Federal Council for Science and Technology, 1970; *Glossary of Stinfo Terminology*, Office of Aerospace Research, U.S. Air Force, 1963; *Naval Dictionary of Electronic, Technical, and Imperative Terms*, Bureau of Naval Personnel, 1962; *ADP Glossary*, Department of the Navy, NAVSO P-3097.

McGRAW-HILL DICTIONARY OF SCIENTIFIC AND
TECHNICAL TERMS,
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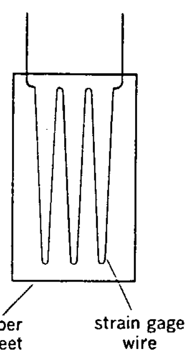
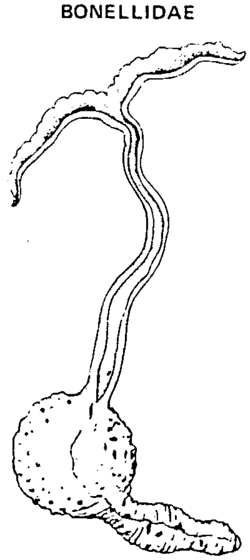
BONDED STRAIN GAGE



Elements of a bonded strain gage.

BONELLIDAE



Bonellia species, half size, showing the long and cleft (at the top) prostomium characteristic of the Bonellidae.

bomb rack [ORD] A mechanical device, fitted to an airplane in the bomb bay or suspended underneath the plane, that releases and arms bombs at the bombardier's or pilot's command.

bomb reconnaissance [ORD] Reconnoitering to determine the presence of an unexploded missile, ascertaining its nature, applying all practicable protective measures for the protection of personnel, installations, and equipment, and finally reporting essential information to the authority directing explosive ordnance disposal operations.

bomb-release line [ORD] An imaginary line around a target area at which a bomber, traveling toward it at a constant speed and altitude, releases its first bomb so that it and others will strike the target area.

bomb-release point [ORD] The point in flight on a bomb run at which a bombing airplace releases its bomb load.

bomb run [ORD] The flight course of a bombing airplane just before the release of bombs.

bomb sag [GEOL] Depressed and deranged laminae mainly found in beds of fine-grained ash or tuff around an included volcanic bomb or block which fell on and became buried in the deposit.

bomb shelter [CIV ENG] A bomb-proof structure for protection of people.

bombsight [ORD] A device which determines, or enables a bombardier to determine, the point in space at which a bomb must be released from an aircraft in order to hit a target.

bomb test [ENG] A leak-testing technique in which the vessel to be tested is immersed in a pressurized fluid which will be driven through any leaks present.

Bombycidae [INV ZOO] A family of lepidopteran insects of the superorder Heteroneura that includes only the silkworms.

Bombyliidae [INV ZOO] The bee flies, a family of dipteran insects in the suborder Orthorrhapha.

Bombyx [INV ZOO] The type genus of Bombycidae.

Bombyx mori [INV ZOO] The commercial silkworm.

bond [CHEM] The strong attractive force that holds together atoms in molecules and crystalline salts. Also known as chemical bond. [ELEC] The connection made by bonding electrically. [ENG] **1.** A wire rope that fixes loads to a crane hook. **2.** Adhesion between cement or concrete and masonry or reinforcement. [MET] **1.** Material added to molding sand to impart bond strength. **2.** Junction of the base metal and filler metal, or the base metal beads, in a welded joint.

Bond and Wang theory [MECH ENG] A theory of crushing and grinding from which the energy, in horsepower-hours, required to crush a short ton of material is derived.

bond angle [PHYS CHEM] The angle between bonds sharing a common atom. Also known as valence angle.

bond clay [MATER] A type of clay with high plasticity and high dry strength used to bond nonplastic materials; may be refractory.

bond distance [PHYS CHEM] The distance separating the two nuclei of two atoms bonded to each other in a molecule. Also known as bond length.

bonded coating [MATER] A finishing or protecting layer of any compound affixed to a surface.

bonded NR diode [ELECTR] An n^+ junction semiconductor device in which the negative resistance arises from a combination of avalanche breakdown and conductivity modulation which is due to the current flow through the junction.

bonded-phase chromatography [ANALY CHEM] A type of high-pressure liquid chromatography which employs a stable, chemically bonded stationary phase.

bonded strain gage [ENG] A strain gage in which the resistance element is a fine wire, usually in zigzag form, embedded in an insulating backing material, such as impregnated paper or plastic, which is cemented to the pressure-sensing element.

bonded transducer [ENG] A transducer which employs a bonded strain gage for sensing pressure.

bond energy [PHYS CHEM] The heat of formation of a molecule from its constituent atoms.

bonderize [MET] To coat steel with a solution of phosphates for corrosion protection.

bond hybridization [CHEM] The linear combination of two or more simple atomic orbitals.

bonding [CHEM] The joining together of atoms to form molecules or crystalline salts. [ELEC] The use of low-resistance material to connect electrically a chassis, metal shield cans, cable shielding braid, and other supposedly equipotential points to eliminate undesirable electrical interaction resulting from high-impedance paths between them. [ENG] **1.** The fastening together of two components of a device by means of adhesives, as in anchoring the copper foil of printed wiring to an insulating baseboard. **2.** *See* cladding. [TEXT] The joining of two fabrics, usually a face fabric and a lining fabric.

bonding agent [MATER] Any substance that fixes one material to another.

bonding electron [PHYS CHEM] An electron whose orbit spans the entire molecule and so assists in holding it together.

bonding orbital [PHYS CHEM] A molecular orbital formed by a bonding electron whose energy decreases as the nuclei are brought closer together, resulting in a net attraction and chemical bonding.

bonding pad [ELECTR] A metallized area on the surface of a semiconductor device, to which connections can be made.

bonding strength [MECH] Structural effectiveness of adhesives, welds, solders, glues, or of the chemical bond formed between the metallic and ceramic components of a cermet, when subjected to stress loading, for example, shear, tension, or compression.

bonding wire [ELEC] Wire used to connect metal objects so they have the same potential (usually ground potential).

bond length *See* bond distance.

Bond number [FL MECH] A dimensionless number used in the study of atomization and the study of bubbles and drops, equal to $(\rho-\rho')L^2g/\sigma$, where ρ is the density of a bubble or drop, ρ' is the density of the surrounding medium, L is a characteristic dimension, g is the acceleration of gravity, and σ is the surface tension of the bubble or drop.

bond paper [MATER] A paper used for writing paper, business forms, and typewriter paper; the less expensive bond papers are made from wood sulfite pulps; rag-content bonds contain 25, 50, 75, or 100% of pulp made from rags, and offer greater permanence and strength.

Bond's law [MECH ENG] A statement that relates the work required for the crushing of solid materials (for example, rocks and ore) to the product size and surface area and the lengths of cracks formed. Also known as Bond's third theory.

Bond's third theory *See* Bond's law.

bondstone [BUILD] A stone joining the coping above a gable to the wall. [CIV ENG] A stone that passes through a masonry wall in order to hold the wall together.

bone [ANAT] One of the parts constituting a vertebrate skeleton. [HISTOL] A hard connective tissue that forms the major portion of the vertebrate skeleton.

Bone Age [ARCHEO] A prehistoric period of human culture characterized by the use of implements made of bone and antler.

bone ash [CHEM] A white ash consisting primarily of tribasic calcium phosphate obtained by burning bones in air; used in cleaning jewelry and in some pottery.

bone bed [GEOL] Several thin strata or layers with many fragments of fossil bones, scales, teeth, and also organic remains.

bone black [MATER] A black substance made by carbonizing crushed, defatted bones in closed vessels; used as a paint and varnish pigment, as a decolorizing absorbent in clarifying shellac, in cementation, and in gas masks. Also known as animal black; bone char.

bone char *See* bone black.

bone chert [PETR] A weathered residual chert that appears chalky and porous with a white color but may be stained red or other colors.

bone coal [GEOL] Argillaceous coal or carbonaceous shale that is found in coal seams.

bone conduction [BIOPHYS] Transmission of sound vibrations to the internal ear via the bones of the skull.

Bonellidae [INV ZOO] A family of wormlike animals belonging to the order Echiuroinea.

bone marrow [HISTOL] A vascular modified connective tissue occurring in the long bones and certain flat bones of vertebrates.

bone meal [MATER] A substance made by grinding animal bones; steamed meal, made from pressure-steamed bones, is used as a fertilizer; raw meal is used in animal feed.

bone oil [MATER] Dark brown oil with a disagreeable odor, derived by destructive distillation of bones or other animal substances; used as an alcohol denaturant, an insecticide, or a source of pyrrole and for organic preparations. Also known as animal oil; Dippel's oil; hartshorn oil; Jeppel's oil.

bone seeker [NUCLEO] A radioisotope that tends to ac-

posits formed from warm waters at shallow depth, at temperatures ranging from 50–200°C, and generally at some distance from the magnetic source.

epithermal deposit [GEOL] Ore deposit formed in and along openings in rocks by deposition at shallow depths from ascending hot solutions.

epithermal neutron [NUCLEO] A neutron having an energy in the range immediately above the thermal range, roughly between 0.02 and 100 electron volts.

epithermal reactor [NUCLEO] A nuclear reactor in which a substantial fraction of fissions is induced by neutrons having more than thermal energy.

epithermal thorium reactor [NUCLEO] A sodium-cooled reactor based on operation with neutrons in the high epithermal energy range; a uranium-thorium fuel mixture is used, with graphite or beryllium as moderator.

epitoke [INV ZOO] The posterior portion of marine polychaetes; contains the gonads.

epitope [IMMUNOL] A single determinant of an antigen or immunogen which influences its specificity (immunology).

epitrichium [EMBRYO] The outer layer of the fetal epidermis of many mammals.

epitrochlear [ANAT] Of or pertaining to a lymph node that lies above the trochlea of the elbow joint.

epitrochoid [MATH] A curve traced by a point rigidly attached to a circle at a point other than the center when the circle rolls without slipping on the outside of a fixed circle.

epituberculosis [MED] A massive pulmonary shadow seen in x-ray films in active juvenile tuberculosis, probably caused by bronchial obstruction.

epitympanum [ANAT] The attic of the middle ear, or tympanic cavity.

epivalve [INV ZOO] **1.** The upper or apical shell of certain dinoflagellates. **2.** The upper shell of a diatom.

epixylous [ECOL] Growing on wood; used especially of fungi.

epizoic [BIOL] Living on the body of an animal.

epizone [GEOL] **1.** The zone of metamorphism characterized by moderate temperature, low hydrostatic pressure, and powerful stress. **2.** The outer depth zone of metamorphic rocks.

epizootic [VET MED] **1.** Affecting many animals of one kind in one region simultaneously; widely diffuse and rapidly spreading. **2.** An extensive outbreak of an epizootic disease.

epizootiology [VET MED] The study of epizootics.

E-plane antenna [ELECTROMAG] An antenna which lies in a plane parallel to the electric field vector of the radiation that it emits.

E-plane bend *See* E bend.

E-plane T junction [ELECTROMAG] Waveguide T junction in which the change in structure occurs in the plane of the electric field. Also known as series T junction.

EP lubricant [MATER] A lubricating oil or grease that contains additives to improve ability to adhere to the surfaces of metals under high bearing pressures. Derived from extreme-pressure lubricant.

EPN *See* *O*-ethyl-*O*-*para*-nitrophenyl phenylphosphonothioate.

epoch [ASTRON] A particular instant for which certain data are valid; for example, star positions in an astronomical catalog, epoch 1950.0. [GEOL] A major subdivision of a period of geologic time. [PHYS] *See* time.

eponychium [ANAT] The horny layer of the nail fold attached to the nail plate at its margin; represents the remnant of the embryonic condition. [EMBRYO] A horny condition of the epidermis from the second to the eighth month of fetal life, indicating the position of the future nail.

epoophoron [ANAT] A blind longitudinal duct and 10–15 transverse ductules in the mesosalpinx near the ovary which represent remnants of the reproductive part of the mesonephros in the female; homolog of the head of the epididymis in the male. Also known as parovarium; Rosenmueller's organ.

epoxidation [ORG CHEM] Reaction yielding an epoxy compound, such as the conversion of ethylene to ethylene oxide.

epoxide [ORG CHEM] A reactive group in which an oxygen atom is joined to each of two carbon atoms which are already bonded.

epoxy- [ORG CHEM] A prefix indicating presence of an epoxide group in a molecule.

epoxy adhesive [MATER] An adhesive material made of epoxy resin.

1,2-epoxybutane *See* 1,2-butylene oxide.

1,2-epoxyethane *See* ethylene oxide.

2,3-epoxy-1-propanol *See* glycidol.

epoxy resin [ORG CHEM] A polyether resin formed originally by the polymerization of bisphenol A and epichlorohydrin, having high strength, and low shrinkage during curing; used as a coating, adhesive, casting, or foam.

Eppley pyrheliometer [ENG] A pyrheliometer of the thermoelectric type; radiation is allowed to fall on two concentric silver rings, the outer covered with magnesium oxide and the inner covered with lampblack; a system of thermocouples (thermopile) is used to measure the temperature difference between the rings; attachments are provided so that measurements of direct and diffuse solar radiation may be obtained.

EPR *See* electron paramagnetic resonance.

EPROM *See* erasable programmable read-only memory.

epsilcapromin *See* ϵ-aminocaproic acid.

epsilon meson [PARTIC PHYS] Neutral, scalar, meson resonance having positive charge conjugation parity and G-parity, a mass of about 730 MeV, and a width of about 600 MeV; decays to two pions.

epsilon neighborhood [MATH] The set of all points in a metric space whose distance from a given point is less than some number; this number is designated ϵ.

epsilon structure [SOLID STATE] The hexagonal close-packed structure of the ϵ-phase of an electron compound.

epsomite [MINERAL] $MgSO_4 \cdot 7H_2O$ A mineral that occurs in clear, needlelike, orthorhombic crystals; commonly, it is massive or fibrous; luster varies from vitreous to milky, hardness is 2–2.5 on Mohs scale, and specific gravity is 1.68; it has a salty bitter taste and is soluble in water. Also known as epsom salt.

epsom salt *See* epsomite.

Epstein-Barr virus [VIROL] Herpeslike virus particles first identified in cultures of cells from Burkett's malignant lymphoma.

EPT *See* ethylene-propylene terpolymer.

epulis [MED] A benign tumorlike lesion of the gingiva.

equal [MATH] Being the same in some sense determined by context.

equal altitudes [NAV] In celestial navigation, two altitudes numerically the same; the expression applies particularly to the now obsolescent practice of determining the instant of local apparent noon by observing the altitude of the sun a short time before it reaches the meridian and again at the same altitude after transit; the time of local apparent noon is midway between the times of the two observations; however the second observation must be corrected for the run of the ship which took place between the times of the two readings. Also known as double altitudes.

equal-area latitude *See* authalic latitude.

equal-area map projection [MAP] A map projection having a constant area scale; it is not conformal and is not used for navigation. Also known as authalic map projection; equivalent map projection.

equal-arm balance [MECH] A simple balance in which the distances from the point of support of the balance-arm beam to the two pans at the end of the beam are equal.

equal-energy source [PHYS] Electromagnetic or sound source of energy which emits the same amount of energy for each frequency of the spectrum.

equaling file [DES ENG] A slightly bulging double-cut file used in fine toolmaking.

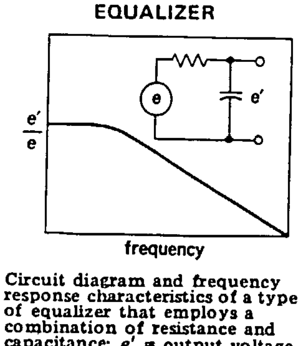
equality [MATH] The state of being equal.

equality gate *See* equivalence gate.

equalization [ELECTR] The effect of all frequency-discriminating means employed in transmitting, recording, amplifying, or other signal-handling systems to obtain a desired overall frequency response. Also known as frequency-response equalization.

equalizer [ELECTR] A network designed to compensate for an undesired amplitude-frequency or phase-frequency response of a system or component; usually a combination of coils, capacitors, and resistors. Also known as equalizing circuit. [MECH ENG] **1.** A bar to which one attaches a vehicle's whiffletrees to make the pull of draft animals equal. Also known as equalizing bar. **2.** A bar which joins a pair of axle springs on a railway locomotive or car for equalization of weight. Also known as equalizing bar. **3.** A device which distributes braking force among independent brakes of an automotive vehicle. Also known as equalizer brake. **4.** A machine

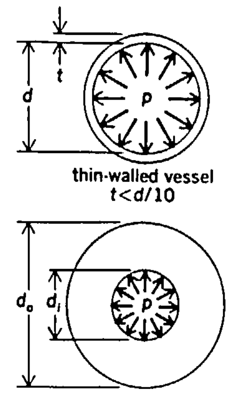
EQUALIZER



Circuit diagram and frequency response characteristics of a type of equalizer that employs a combination of resistance and capacitance; e' = output voltage, e = input voltage.

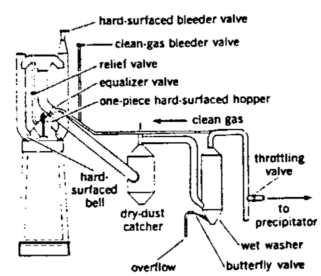
pressure vessel [ENG] A metal container generally cylindrical or spheroid, capable of withstanding bursting pressures.
pressure viscosity [FL MECH] Property of petroleum lubricating oils to increase in viscosity when subjected to pressure.
pressure wave [METEOROL] A wave or periodicity which exists in the variation of atmospheric pressure on any time scale, usually excluding normal diurnal or seasonal trends. [PHYS] *See* compressional wave.
pressure welding [MET] Welding of metal surfaces by the application of pressure; examples are percussion welding, resistance welding, seam welding, and spot welding.
pressurization [ENG] **1.** Use of an inert gas or dry air, at several pounds above atmospheric pressure, inside the components of a radar system or in a sealed coaxial line, to prevent corrosion by keeping out moisture, and to minimize high-voltage breakdown at high altitudes. **2.** The act of maintaining normal atmospheric pressure in a chamber subjected to high or low external pressure.
pressurize [ENG] To maintain normal atmospheric pressure in a chamber subjected to high or low external pressures.
pressurized blast furnace [ENG] A blast furnace operated under pressure above the ambient; pressure is obtained by throttling the off-gas line, which permits a greater volume of air to be passed through the furnace at a lower velocity, and results in increase in smelting rate.
pressurized stoppings [MIN ENG] Stoppings which are erected in the intake and return roadways of a district to isolate an open fire or spontaneous heating and in which the pressures on both sides of each stopping are made equal by the use of auxiliary fans.
pressurized water reactor [NUCLEO] A nuclear reactor in which water is circulated under enough pressure to prevent it from boiling, while serving as moderator and coolant for the uranium fuel; the heated water is then used to produce steam for a power plant. Abbreviated PWR.
presswork [GRAPHICS] In printing, the actual operation of putting ink on paper; this activity is preceded by composition and perhaps platemaking, and is followed by binding.
prester [METEOROL] A whirlwind or waterspout accompanied by lightning in the Mediterranean Sea and Greece.
prestore [COMPUT SCI] To store a quantity in an available computer location before it is required in a routine.
prestress [ENG] To apply a force to a structure to condition it to withstand its working load more effectively or with less deflection. [GEOL] *See* preconsolidation pressure.
prestressed concrete [MATER] Concrete compressed with heavily loaded wires or bars to reduce or eliminate cracking and tensile forces.
presumptive address *See* address constant.
presumptive instruction *See* basic instruction.
presuppression [GEOPHYS] In seismic prospecting, the suppression of the early events on a seismic record for control of noise and reflections on that portion of the record.
pretensioning [ENG] Process of precasting concrete beams with tensioned wires embedded in them. Also known as Hoyer method of prestressing.
pretersonics *See* acoustoelectronics.
pre-transmit-receive tube *See* pre-TR tube.
pretravel [CONT SYST] The distance or angle through which the actuator of a switch moves from the free position to the operating position.
pretrigger [ELECTR] Trigger used to initiate sweep ahead of transmitted pulse.
pre-TR tube [ELECTR] Gas-filled radio-frequency switching tube used in some radar systems to protect the TR tube from excessively high power and the receiver from frequencies other than the fundamental. Derived from pre-transmit-receive tube.
prevailing current [OCEANOGR] The ocean current most frequently observed during a given period, such as a month, a season, or a year.
prevailing visibility [METEOROL] In United States weather observing practice, the greatest horizontal visibility equaled or surpassed throughout half of the horizon circle; in the case of rapidly varying conditions, it is the average of the prevailing visibility while the observation is being taken.
prevailing westerlies [METEOROL] The prevailing westerly winds on the poleward sides of the subtropical high-pressure belts.
prevailing wind *See* prevailing wind direction.
prevailing wind direction [METEOROL] The wind direction most frequently observed during a given period; the periods most often used are the observational day, month, season, and year. Also known as prevailing wind.
preventive maintenance [ENG] A procedure of inspecting, testing, and reconditioning a system at regular intervals according to specific instructions, intended to prevent failures in service or to retard deterioration.
previewing [COMPUT SCI] In character recognition, a process of attempting to gain prior information about the characters that appear on an incoming source document; this information, which may include the range of ink density, relative positions, and so forth, is used as an aid in the normalization phase of character recognition.
previous element coding [COMMUN] System of signal coding, used for digital television transmission, whereby each transmitted picture element is dependent upon the similarity of the preceding picture element.
previtrain [GEOL] The woody lenses in lignite that are equivalent to vitrain in coal of higher rank.
Prevost's theory [THERMO] A theory according to which a body is constantly exchanging heat with its surroundings, radiating an amount of energy which is independent of its surroundings, and increasing or decreasing its temperature depending on whether it absorbs more radiation than it emits, or vice versa.
preweld interval [MET] In resistance spot welding, elapsed time between the end of squeeze time and the beginning of welding current.
prewhitening filter *See* whitening filter.
PRF *See* pulse repetition rate.
pri *See* primary winding.
Priabonian [GEOL] A European stage of geologic time in the upper Eocene, believed to consist of Auversian and Bartonian.
priapism [MED] Persistent erection of the penis, usually unaccompanied by sexual desire, as seen in certain pathologic conditions.
Priapulida [INV ZOO] A minor phylum of wormlike marine animals; the body is made up of three distinct portions (proboscis, trunk, and caudal appendage) and is often covered with spines and tubercles, and the mouth is surrounded by concentric rows of teeth.
Priapuloidea [INV ZOO] An equivalent name for Priapulida.
priceite [MINERAL] $Ca_4B_{10}O_{19}\cdot 7H_2O$ A snow-white earthy mineral composed of hydrous calcium borate, occurring as a massive. Also known as pandermite.
Price meter [ENG] The ocean current meter in use in the United States: six conical cups, mounted around a vertical axis, rotate and cause a signal in a set of headphones with each rotation; tail vanes and a heavy weight stabilize the instrument.
pricker *See* needle.
prickly heat *See* miliaria.
prick punch [DES ENG] A tool that has a sharp conical point ground to an angle of 30–60°C; used to make a slight indentation on a workpiece to locate the intersection of centerlines.
priest [OPTICS] The Z tristimulus value.
prill [CHEM ENG] To form pellet-sized crystals or agglomerates of material by the action of upward-blowing air on falling hot solution; used in the manufacture of ammonium nitrate and urea fertilizers. [MATER] Spherical particles about the size of buckshot. [MIN ENG] **1.** The best ore after cobbing. **2.** A circular particle about the size of buckshot. **3.** Compressed and sized explosives such as ammonium nitrate.
primaquine [PHARM] $C_{15}H_{21}N_3O$ An ether-soluble viscous liquid, used as the diphosphate salt in medicine to cure malaria.
primary [ASTRON] **1.** A planet with reference to its satellites, or the sun with reference to its planets. **2.** The brighter star of a double star system. [CHEM] A term used to distinguish basic compounds from similar or isomeric forms; in organic compounds, for example, RCH_2OH is a primary alcohol, R_1R_2CHOH is a secondary alcohol, and $R_1R_2R_3COH$ is a tertiary alcohol; in inorganic compounds, for example, NaH_2PO_4 is primary sodium phosphate, Na_2HPO_4 is the secondary form, and Na_3PO_4 is the tertiary form. [ELEC] **1.** *See* primary winding. **2.** One of the high-voltage conductors of a power distribution system. [GEOL] **1.** A young shoreline whose features are produced chiefly by nonmarine agencies. **2.** Of a mineral deposit, unaffected by supergene enrichment. [MET] Of a metal, obtained directly from ore. [VERT ZOO] Of or pertaining to quills on the distal joint of a bird wing.

PRESSURE VESSEL



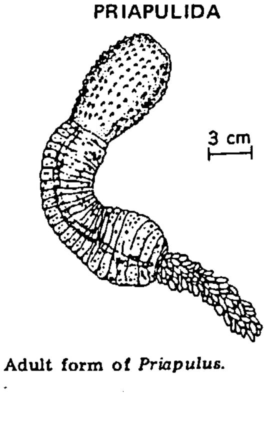
Pressure vessels for moderate and for high pressures; t = wall thickness; d = vessel diameter; p = pressure; d_i, d_o = inside and outside diameters.

PRESSURIZED BLAST FURNACE



Flow diagram of a pressurized blast furnace.

PRIAPULIDA



Adult form of *Priapulus*.

on or against the shoulder when firing, as a rifle, c[illegible]e, or bazooka launcher.

shoved moraine *See* push moraine.

shovel [DES ENG] A hand tool having a flattened scoop at the end of a long handle for moving soil, aggregate, cement, or other similar material. [MECH ENG] A mechanical excavator.

shovel dozer *See* tractor loader.

shovel loader [MECH ENG] A loading machine mounted on wheels, with a bucket hinged to the chassis which scoops up loose material, elevates it, and discharges it behind the machine.

Showalter stability index [METEOROL] A measure of the local static stability of the atmosphere, expressed as a numerical index.

show-card color *See* poster paint.

shower [METEOROL] Precipitation from a convective cloud; characterized by the suddenness with which it starts and stops, by the rapid changes of intensity, and usually by rapid changes in the appearance of the sky. [NUC PHYS] *See* cosmic-ray shower.

shower meteor [ASTRON] A meteor whose direction of arrival is approximately parallel to others belonging to the same meteor shower.

shower unit [NUCLEO] The mean path length required to reduce the energy of relativistic charged particles to half value as they pass through matter; one shower unit is equal to 0.693 radiation length.

show-through [GRAPHICS] In printing, an undesirable result in which the printing is visible through the sheet under normal lighting conditions. Also known as strike-through.

shrapnel [ORD] Small lead or steel balls contained in a shrapnel case which is fired from an artillery piece; the balls are projected in a forward direction upon the functioning of the fuse.

shrew [VERT ZOO] Any of more than 250 species of insectivorous mammals of the family Soricidae; individuals are small with a moderately long tail, minute eyes, a sharp-pointed snout, and small ears.

Shrike [ORD] An air-to-surface solid-fuel guided missile that homes in on enemy radar installations.

shrimp [INV ZOO] The common name for a number of crustaceans, principally in the decapod suborder Natantia, characterized by having well-developed pleopods and by having the abdomen sharply bent in most species, producing a humped appearance.

shrinkage [ENG] **1.** Contraction of a molded material, such as metal or resin, upon cooling. **2.** Contraction of a plastics casting upon polymerizing. [GEOL] The decrease in volume of soil, sediment, fill, or excavated earth due to the reduction of voids by mechanical compaction, superimposed loads, natural consolidation, or drying.

shrinkage cavity [MET] A cavity resulting from shrinkage during casting.

shrinkage crack [GEOL] A small crack produced in fine-grained sediment or rock by the loss of contained water during drying or dehydration. [MET] An irregular interdendritic crack in a casting caused by unequal contraction or inadequate feeding.

shrinkage index [GEOL] The numerical difference between the plastic limit of a material and its shrikage limit.

shrinkage limit [GEOL] That moisture content of a soil below which a decrease in moisture content will not cause a decrease in volume, but above which an increase in moisture will cause an increase in volume.

shrinkage pore [GEOL] An irregular pore formed in muddy sediment by shrinkage.

shrinkage ratio [GEOL] The ratio of a volume change to the moisture-content change above the shrinkage limit.

shrinkage rule *See* contraction rule.

shrinkage stoping [MIN ENG] A modification of overhead stoping, involving the use of a part of the ore for the purpose of support and as a working platform. Also known as back stoping.

shrink fit [DES ENG] A tight interference fit between mating parts made by shrinking-on, that is, by heating the outer member to expand the bore for easy assembly and then cooling so that the outer member contracts.

shrink forming [DES ENG] Forming metal wherein the piece undergoes shrinkage during cooling following the application of heat, cold upset, or pressure.

shrink-mixed concrete [MATER] Concrete [illegible]s partially mixed before being put in a truck mixer.

shrink ring [DES ENG] A heated ring placed on an assembly of parts, which on subsequent cooling fixes them in position by contraction.

shrink rule *See* contraction rule.

shrink wrapping [ENG] A technique of packaging with plastics in which the strains in plastics film are released by raising the temperature of the film, causing it to shrink-fit over the object being packaged.

shroud [ENG] A protective covering, usually of metal plate or sheet. [HOROL] The ends of lantern clock pinions that hold the pins. [NAV ARCH] A principal member of the standing rigging consisting of hemp or wire ropes which extend from or near a masthead to a vessel's side or to the rim of the top of the mast to afford lateral support for the mast.

shrouded propeller *See* ducted fan.

shrub [BOT] A low woody plant with several stems.

shrub-coppice dune [GEOL] A small dune formed on the leeward side of bush-and-clump vegetation.

Shubnikov–de Haas effect [SOLID STATE] Oscillations of the resistance or Hall coefficient of a metal or semiconductor as a function of a strong magnetic field, due to the quantization of the electron's energy.

Shubnikov groups [SOLID STATE] The point groups and space groups of crystals having magnetic moments. Also known as black-and-white groups; magnetic groups.

shuga [OCEANOGR] A spongy, rather opaque, whitish chunk of ice which forms instead of pancake ice if the freezing takes place in sea water which is considerably agitated.

shungite [GEOL] A hard, black, amorphous, coallike material composed of more than 98% carbon.

shunt [ELEC] **1.** A precision low-value resistor placed across the terminals of an ammeter to increase its range by allowing a known fraction of the circuit current to go around the meter. Also known as electric shunt. **2.** To place one part in parallel with another. **3.** *See* parallel. [ELECTROMAG] A piece of iron that provides a parallel path for magnetic flux around an air gap in a magnetic circuit. [MED] A vascular passage by which blood is diverted from its normal circulatory path; frequently it is a surgical passage created between two blood vessels, but it may also be an anatomical feature. [MIN ENG] To shove or turn off to one side, as a car or train from one track to another.

shunt-excited [ELECTROMAG] Having field windings connected across the armature terminals, as in a direct-current generator.

shunt-excited antenna [ELECTROMAG] A tower antenna, not insulated from the ground at the base, whose feeder is connected at a point about one-fifth of the way up the antenna and usually slopes up to this point from a point some distance from the antenna's base.

shunt-fed vertical antenna [ELECTROMAG] Vertical antenna connected to the ground at the base and energized at a point suitably positioned above the grounding point.

shunt feed *See* parallel feed.

shunt generator [ELEC] A generator whose field winding and armature winding are connected in parallel, and in which the armature supplies both the load current and the field current.

shunting [ELEC] The act of connecting one device to the terminals of another so that the current is divided between the two devices in proportion to their respective admittances.

shunt loading [ELEC] Loading in which reactances are applied in shunt across the conductors.

shunt motor [ELEC] A direct-current motor whose field circuit and armature circuit are connected in parallel.

shunt neutralization *See* inductive neutralization.

shunt peaking [ELECTR] The use of a peaking coil in a parallel circuit branch connecting the output load of one stage to the input load of the following stage, to compensate for high-frequency loss due to the distributed capacitances of the two stages.

shunt reactor [ELEC] A reactor that has a relatively high inductance and is wound on a magnetic core containing an air gap; used to neutralize the charging current of the line to which it is connected.

shunt regulator [ELEC] A regulator that maintains a constant output voltage by controlling the current through a dropping resistance in series with the load.

shunt repeater [ELEC] A type of negative impedance tele-

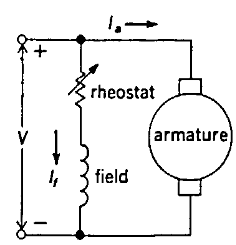
SHREW

The Eurasian common shrew *(Sorex araneus)* has the soft, velvetlike fur characteristic of all shrews.

SHRIMP

Common shrimp *(Crangon vulgaris)*, with a laterally compressed body and curved abdomen.

SHUNT MOTOR



Circuit diagram showing connections of shunt motor. V = total impressed voltage from line; I_a = total armature current; I_f = field current.

REISSUE APPLICATION

CLAIM COMPARISON SHEETS

Concise Descriptions of Relevance Are Found On Each Claim Comparison Sheet

REFERENCES AND BASES FOR REJECTION

1.	Claims 1 and 18	Ref. A Pierce '979 (Figs. 3a, 3b, and 3c) 35 U.S.C. 102 (b) or 103 (electrode not flat)
2.	Claims 1 and 18	Ref. A Pierce '979 (Figs. 4a, 4b, 5, and 6(plus Ref. B McGuire 35 U.S.C. 103
3.	Claims 1 and 18	Ref. A Pierce '979 plus Ref. D Horiuchi '135 (Fig. 1) 35 U.S.C. 103
4.	Claims 1 and 18	Ref. A Pierce '979 plus Ref. D Horiuchi '135 (Fig. 14) 35 U.S.C. 103
5.	Claims 1 and 18	Ref. G Steinberg '114 35 U.S.C. 102(b)
6.	Claims 1 and 18	Ref. A Pierce '979 plus Ref. H Mundt '162 35 U.S.C. 103
7.	Claims 1 and 18	Ref. A Pierce '979 plus Ref. I Horiuchi '713 (Fig. 1) 35 U.S.C. 103 or 102
8.	Claims 1 and 18	Ref. A Pierce '979 plus Ref. I Horiuchi '713 (Fig. 6) 35 U.S.C. 103
9.	Claims 1 and 18	Ref. A Pierce '979 and/or Ref. J Rose '378 (Fig. 1) 35 U.S.C. 103 or 102(b)
10.	Claims 1 and 18	Ref. A Pierce '979 plus Ref. K Hidler '091 (Figs. 1 and 2) 35 U.S.C. 103

11.	Claim 2	Ref. D Horiuchi '135 (Figs. 1 and 14)
		35 U.S.C. 102(b) or 103
12.	Claim 2	Ref. I Horiuchi '713 (Figs. 1 and 6)
		35 U.S.C. 102(b) or 103
13.	Claim 2	Ref. G Steinberg et al. '114 35 U.S.C. 102(b) or 103
14.	Claims 3, 4 and 19	Ref. B McGuire or Ref. D Horiuchi '135 (Fig 1)
15.	Claims 3, 4 and 19	Ref. D Horiuchi '135 (Fig. 14) or Ref. F (Fig. 30c)
		35 U.S.C. 103
16.	Claims 3, 4 and 19	Ref. H Hidler '091 (Figs. 4 and 5) 35 U.S.C. 103
17.	Claims 3, 4 and 19	Ref. I Horiuchi '713 (Figs. 1 and 6)
18.	Claim 5	Ref. A Pierce '979 (Figs. 3a, 3b, and 3c) Ref. B (Fig. 51aiii)
		35 U.S.C. 102(b) or 103
19.	Claim 5	Ref. A Pierce '979 (Figs. 4a, 4b, particularly <u>5 and 6</u>)
		35 U.S.C. 102(b) or 103
20..	Claim 5	Ref. B McGuire (Figs 3a, 3b and 3c; Fig. 51aiii)
		35 U.S.C. 103
21.	Claim 5	Ref. C Wickersham (Figs. 1, 2 and 3) 35 U.S.C. 103
22.	Claim 5	Ref. D Horiuchi '135 (Figs. 1 and 14) 35 U.S.C. 102(b)
23.	Claim 5	Ref. F Loewenstein '621 (Fig. 30c) 35 U.S.C. 103
24.	Claim 5	Ref. I Horiuchi '713 (Figs 1 and 6)
		35 U.S.C. 102(b) or 103
25.	Claims 6 and 20	Ref. C Wickersham '435 (Figs. 1, 2 and 3)

26. Claims 7 and 21 Ref. A Pierce '979 (Figs. 3a, 3b, and 3c)
35 U.S.C. 102(b) or 103

27. Claims 7 and 21 Ref. A Pierce '979 (Figs 4a and 4b)
35 U.S.C. 102(b) or 103

28. Claims 7 and 21 Ref. D Horiuchi '135 (Figs. 1 and 14)

29. Claims 7 and 21 Ref. G Steinberg '114 (The figure) 35 U.S.C. 102(b)

30. Claims 8 and 22 Ref. F Loewenstein '621 or Ref. H Mundt '162 (see chart)
35 U.S.C. 103 or 112

31. Claims 8 and 22 Ref. I Horiuchi '713 (see chart) 35 U.S.C. 103 or 112

32. Claims 8 and 22 Degner '456 admissions, Col. 4, lines 21-25l 35 U.S.C. 112

33. Claims 9 and 23 Degner '456 admissions, Col. 5, lines 18-23 35 U.S.C. 112

34. Claims 10 and 24 Ref. A Pierce '979, Figs. 3a-6, Elements 215, 315, 415, 515, and 615 35 U.S.C. 103

35. Claims 10 and 24 Ref. K Hidler '091, Figs. 1 and 2 bonding layer 16
35 U.S.C. 102(b) and 103

36. Claims 11 and 29 Ref. A Pierce '979 alone or with Ref. K, Hidler '091 (see chart) 35 U.S.C. 102(b) or 103

37. Claims 12, 25 and 26 Ref. A Pierce '979 (see chart)
35 U.S.C. 102(a) or 103

38. Claims 12, 25 and 26 Ref. K Hidler '091, (Figs 1 and 2) 35 U.S.C. 103

39. Claims 13 and 27 Ref. A Pierce '979 35 U.S.C. 102(b) or 103

40.	Claims 13 and 27	Ref. C, D and K (See Chart) 35 U.S.C. 102.(b) or 103
41.	Claims 14 and 28	Ref. K Hidler '091 (Figs. 1 and 2, Col. 2, lines 29-61) 35 U.S.C. 102(b)
42.	Claims 15 and 29	Ref. A Pierce '979, (Col. 11, line 44 through Col. 12, line 5) 35 U.S.C. 102(b) or 103
43.	Claims 15 and 29	Ref. K Hidler '091 (Figs. 1 and 2 plus Col. 3, lines 24-50) 35 U.S.C. 102(b) or
44.	Claims 16 and 30	Ref. A Pierce '979 (Col. 2, lines 29-32 and Col. 12, Lines 6-14) 35 U.S.C. 112, 102(b) or 103
45.	Claims 16 and 30	Ref. D Horiuchi '135 (see chart) 35 U.S.C. 112, 102(b) or 103
46.	Claims 16 and 30	Ref. F Loewenstein '621 (Col. 54, lines 33-36) 35 U.S.C. 112, 102(b) or 103
47.	Claims 16 and 30	Ref. G Steinberg '114 (The Fig. and Col. 2, lines 57-60) 35 U.S.C. 112, 102(b) or 103
48.	Claims 17 and 31 Horiuchi '135	Ref. A Pierce 979, Ref. C Wickersham '435, Ref. D Horiuchi '135 (see Chart) 35 U.S.C. 102(b) and 112
49.	Claims 17 and 31	Ref. A Pierce '979, Ref. F Loewenstein '621 or Ref. D Horiuchi '135 (see chart) 35 U.S.C. 102(b) and 112
50.	Claim 32	Re. A. Pierce '979 (see chart) 35 U.S.C. 102(b)

53.	Claim 34	Ref. A Pierce '979 (Col. 13, line 67 through Col. 14, line 14 .particularly Col. 14, lines 8-14) 35 U.S.C. 102(b)
54.	Claim 35	Ref. A Pierce '979, Col. 2, lines 29-31, Col. 12, lines 6-14 35 U.S.C. 102(b)
55.	Claim 35	Ref. D Horiuchi '135, Col. 12, lines 57-60 35 U.S.C. 102(b)
56.	Claim 35	Ref. F Loewenstein '621 Col. 54, lines 33-36 35 U.S.C. 102(b), 112
57.	Claim 35	Ref. G Steinberg '114, Col. 3, lines 60-63, 35 U.S.C. 102(b) 103, or 112
58.	Claim 36	Ref. A, Pierce et al. '979, Col. 13, line 67, Col. 14, line 28, and Figs. 3a, 3b, 3c, 4a, 4b, and particularly Figs. 5 and 6 35 U.S.C. 102(b)
59.	Claim 36	Ref. C Wickersham '435, Col. 6, lines 6-15, Figs. 2 and 3 35 U.S.C. 102(b)